Occlusal characteristics during different emergence stages of the permanent dentition in Tanzanian Bantu and Finnish children

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SUMMARY Occlusal characteristics and anomalies were studied among 869 (428 boys, 441 girls) Tanzanian Bantu children aged 3.5–16 years and 706 (319 boys, 387 girls) Finnish children aged 5–11 years during different emergence stages of the permanent dentition. Various occlusal variables were registered according to described criteria. Multiple linear regression, ANOVA, *t*-test, Chi-square and logistic regression models were used to test for various statistically significant differences between different subgroups.

Significant differences between Tanzanians and Finns were found for malocclusion, neutral and distal molar occlusion, mean values for overjet and overbite, overjet greater than 5 mm, deep bite and anterior open bite (all P < 0.0001). The most prevalent anomalies among Tanzanians were anterior open bite (7–19 per cent), increased overjet (3–19 per cent) and distal molar occlusion (3–16 per cent). For the Finns, distal molar occlusion (18–38 per cent) was the most prevalent anomaly, followed by deep bite (4–22 per cent) and increased overjet (4–40 per cent). An anterior crossbite was rare and equally distributed among the two ethnic groups. Girls had a larger mean value for overbite (P = 0.003) and more often a deep bite (P < 0.01) than boys. Mandibular incisor crowding among children with neutral occlusion (Class I malocclusion) occurred significantly more often among Finnish than Tanzanian children.

In conclusion, various developmental changes in occlusion were observed leading to variation in occlusal characteristics and anomalies according to the emergence stages of the permanent dentition. Most of the classic malocclusions occur among Tanzanian children, but the prevalence differs from that in other parts of the world.

Introduction

Research on the aetiology and expression of malocclusions is based mainly on the Caucasian population (Thilander and Rönning, 1995; Graber and Vanarsdall, 2000; Proffit et al., 2000). However, population norms derived from this ethnic group may not be valid and accurate for other ethnic groups. Applying Caucasian orthodontic standards to other populations may lead to clinical decisions that cause undesired and unexpected outcomes. For example, many orthodontic treatment decisions depend on both the age and eruption stage of the permanent dentition of a subject. It has been shown that permanent teeth in both the first and second transitional periods in African and African-American children emerge into the oral cavity earlier than in their fellow Caucasians of the same chronological age (Garn et al., 1973; Richardson et al., 1975; Lavelle, 1976; Kerosuo, 1990). This implies that comparisons of these two races in community-based epidemiological studies involving chronological age will be misleading. Davidson and Rodd (2001) advocated a comparison based on dental rather than chronological age. However, dental age determination requires the taking of radiographs, a procedure which, from the ethical point of view, is not feasible in community-based epidemiological studies. Chronological age, however, may validly be replaced by emergence stages of the permanent dentition.

Studies comparing African, African-American and Caucasian children have shown that the first two more often have a Class I molar occlusion, distal occlusion and more often neutral (Infante, 1975; Lavelle, 1976; McLain and Proffit, 1985; Kerosuo, 1990; Kerosuo et al., 1991) and mesial occlusions (Infante, 1975; Lavelle, 1976; McLain and Proffit, 1985) than Caucasians. However, studies comparing the prevalence of malocclusion between African and Caucasian children have often used chronological age to compare the subgroups (Infante, 1975; Garner and Butt, 1985; Kerosuo, 1990; Kerosuo et al., 1991). Furthermore, the time from emergence of the permanent teeth into the oral cavity to reach occlusion might also vary in different ethnic groups. Recording the emergence stages of permanent teeth seems to be useful in this context. Occlusion in children in the same emergence stage of the permanent teeth can then be compared regardless of their chronological age, race and geographical differences.

The present study was designed to determine and compare occlusal characteristics and anomalies between Tanzanian Bantu and Finnish children according to gender and emergence stages of the permanent dentition.

Subjects and methods

Subjects

In Tanzania, the study was carried out in the Ilala district, Dar es Salaam. Tanzanian Bantu school children of four age groups were randomly selected from 16 schools from a total of 500 private and public pre-, primary and secondary schools. The schools were selected from different parts of the Ilala district covering areas of different socio-economic background in urban and peri-urban areas. Lists of all children in the 16 schools with information on age, gender and tribe were collected from the schools. For children with an incomplete school record, parents were requested to send the information to the school. Selected children not present at school on the examination days were recalled and examined. A more detailed description of the sampling procedure for the Tanzanian sample can be found elsewhere (Mugonzibwa et al., 2002). In Tanzania, ethical permission was obtained from the Ministry of Health, the Ministry of Education, the City Commission of Dar es Salaam as well as the school authorities. The parents and subjects were informed verbally, after which they could decide whether or not to participate in the study.

The Finnish sample was not collected by random sampling from the whole population, but included all Finnish children in the studied age groups from Juuka rural community, a municipality of about 7500 inhabitants in eastern Finland. A detailed description of the studied children with compulsory attendance at school in Finland is given elsewhere (Pahkala *et al.*, 1991). In Finland, ethical permission was obtained from the ethical committee, University of Kuopio. Registration of malocclusions was performed during annual dental check ups at the school dental clinics.

The Tanzanian sample included 869 Bantu children (428 boys, 441 girls) aged 3.5–5, 6.5–8, 9.5–11 and 15–16 years and the Finnish sample included 706 children (319 boys, 387 girls) aged 5–11 years.

Methods

The clinical examination of the children was conducted by one examiner (EAM) in Tanzania and by four examiners in Finland. The emergence status of the permanent teeth was determined by classifying the emergence of the permanent teeth into the oral cavity of each tooth into four categories (Pahkala *et al.*, 1991):

- 0 = tooth not visible in oral cavity,
- 1 = at least one cusp visible in the oral cavity,
- 2 = entire occlusal surface/mesiodistal width of tooth visible,
- 3 = tooth in occlusion or at the occlusal level if antagonistic tooth not fully erupted.

In addition, extracted permanent teeth were recorded and were converted to emergence category 3 during the data analyses. Emergence scores of the permanent dentition were calculated as the sum of the emergence categories of individual teeth (minimum = 0, maximum = 84) and used to determine the emergence stages of the permanent dentition:

| Emergence stage 0 (ES0) | Complete primary dentition only (ES = 0) |
|-------------------------|---|
| Emergence stage 1 (ES1) | Incomplete first phase of mixed dentition $(1 \le ES \le 35)$ |
| Emergence stage 2 (ES2) | Complete first phase of the mixed dentition $(ES = 36)$ |
| Emergence stage 3 (ES3) | Incomplete second phase of the mixed dentition $(37 \le ES \le 83)$ |
| Emergence stage 4 (ES4) | Complete permanent dentition ($ES = 84$). |

The distribution of the Tanzanian and Finnish children according to gender and emergence stage of the permanent dentition is shown in Table 1.

Dental occlusion was determined clinically according to the criteria described by Björk et al. (1964), with

 Table 1
 Number of subjects according to ethnic group, gender and emergence stages of the permanent dentition.

| Emergence stage | Tanzaı childre | nian Ban en | tu | Finnish children | | | | | |
|-----------------|-------------------|----------------|-------|------------------|-------|-------|--|--|--|
| | Boys | Girls | Total | Boys | Girls | Total | | | |
| ES0 | 111 | 86 | 197 | 16 | 33 | 49 | | | |
| ES1 | 94 | 113 | 207 | 120 | 151 | 271 | | | |
| ES2 | 24 | 40 | 64 | 55 | 56 | 111 | | | |
| ES3 | 92 | 97 | 189 | 128 | 147 | 275 | | | |
| ES4 | 107 | 105 | 212 | _ | _ | _ | | | |
| Total | 428 | 441 | 869 | 319 | 387 | 706 | | | |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of mixed dentition (ES = 36); ES3, incomplete second phase of mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84).

slight modifications by Laine (1984). Neutral occlusion (Class I) was registered when the mesiobuccal cusp of the maxillary first permanent molar occluded in the mesiobuccal groove of the mandibular first permanent molar. Distal (Class II) or mesial (Class III) occlusions were recorded when there was a deviation of at least one half a cusp width distally or mesially at both sides, otherwise it was considered to be Class I. For the primary dentition, the molar relationship was classified as Class I, II or III when the distal plane of the second primary molars in centric occlusion was straight, distal or had a mesial discrepancy, respectively (Foster and Hamilton, 1969). Similarly the primary canine was in a Class I relationship when the tip of the maxillary primary canine occluded in the embrasure of the mandibular primary canine and the first primary molar, Class II when the tip of the maxillary primary canine was anterior to the Class I relationship and Class III when it was posterior to the Class I relationship.

Overjet (mm) was measured from the most labial point of the incisal edge of the right maxillary incisor to the most labial surface of the corresponding mandibular incisor, parallel to the occlusal plane. Maxillary overjet was considered to be increased when the value exceeded 5 mm. Anterior crossbite was recorded as present when the overjet was less than 0 mm.

Overbite (mm) was measured vertically from the incisal edge of the maxillary right central incisor to the incisal edge of the corresponding mandibular right incisor. A deep bite was recorded as present when the overbite exceeded 5 mm. An anterior open bite was recorded as present when no vertical overlap of the incisors was present, and as a lateral open bite when there was a visible space between antagonistic canines and/or premolars and/or molars.

Lateral crossbite was registered as present when the buccal cusps of the maxillary premolars and/or molars occluded lingually to the buccal cusps of the antagonistic mandibular teeth. A buccal scissors bite was recorded as present when any of the maxillary premolars or molars totally occluded to the buccal surface of the antagonistic mandibular teeth.

Crowding in the incisal segment was recorded in millimetres when there was an overlap of two adjacent teeth in the maxilla and mandible. Correspondingly, crowding was defined when the total sum of crowding in the segment was at least 2 mm. Only incisor crowding in children who had neutral occlusion is presented.

In the early mixed dentition period (ES0 and ES1), occlusion in the anterior segment could not always be determined due to shedding of the primary incisors and depending on the emergence category of the permanent incisors. Such cases were recorded as free of deviate occlusion in their anterior segments and were included in the analyses for other occlusal deviations but were excluded for the overjet, overbite and deep bite analyses.

Inter- and intra-examiner consistency

The intra- and inter-examiner consistencies for emergence stage of the permanent dentition were evaluated by Kappa (κ) values based on double measurements of 20 cases. For the dental occlusion variables, intra-examiner consistency for the Tanzanian examiner was calculated using double determinations from hard stone casts of 40 children within an interval of 2 weeks. Inter-examiner consistencies for the Tanzanian and four Finnish examiners were calculated using clinical measurements from 20 Finnish children within an interval of 1–2 weeks.

Statistical analysis

Data processing and analysis were carried out using the statistical package SPSS (SPSS, 1990). For metric variables (overjet and overbite), multiple linear regression analyses were used to assess the statistical effects of ethnicity, gender and emergence stage of the permanent dentition. The overall P-values for the effect of emergence stage were produced by means of three-way ANOVA in which emergence stage was treated as a categorical variable (0 to 4). For all three factors considered, the overall P-values were adjusted for the effects of the remaining two factors. On comparing overjet and overbite mean values between the two ethnic groups, t-tests for independent samples were used. Significant prevalence differences between the two ethnic groups for various occlusal variables according to emergence stage in the permanent dentition were tested using Chi square. With regard to dichotomous outcomes, logistic regression analyses were applied in the same way as the linear regression analyses. In the respective analyses, the data for boys and girls were pooled because only occasional gender differences were found.

Results

For the emergence stage of the permanent dentition, the inter-examiner consistencies varied from satisfactory to excellent, with κ values ranging from 0.84 to 1.00 (Cohen, 1960), while the intra-examiner consistencies were excellent, with κ values varying from 0.93 to 1.00. Intra-examiner consistencies for occlusal variables for the Tanzanian investigator ranged from moderate to perfect agreement, with κ values from 0.54 to 1.00. Correlation coefficients for the metric variables, overjet and overbite, were 0.96-0.98. For the inter-examiner consistency among Finnish investigators, the κ values ranged from -0.05 to 1.00 and between the Tanzanian and Finnish investigators from 0.48 to 1.00. For two Finnish investigators the agreement for lateral open bite was weak (κ –0.05, –0.26 to 0.02 95 per cent confidence limit). Except for the lateral open bite, the agreements were fair to perfect.

Overall and in each specific emergence stage, Tanzanian children had significantly less malocclusions than Finnish children (Table 2). In both ethnic groups, malocclusion increased with emergence stage but tapered off during the second phase of the mixed dentition (ES3).

Table 3 shows that, generally, Tanzanian children had a neutral molar occlusion more often than Finnish children, only being statistically significant at ES1 and ES2. Neutral occlusion tended to decrease with emergence stage from ES0 to ES2 among Tanzanians and Finns. The overall effects of ethnicity and emergence stage were statistically significant (P < 0.0001 and P = 0.001).

Prevalence (percentage) and 95 per cent confidence intervals of incisor crowding in Tanzanian and Finnish children with neutral molar occlusion (Class I malocclusion) according to emergence stages of the permanent dentition are presented in Table 4. Crowding was more frequent in the mandible than in the maxilla and generally tended to increase with emergence stage. In Tanzanian children, incisor crowding was most frequent in the maxilla at ES2 and lowest in the primary dentition in both arches, and at ES3 in the maxilla. In the maxilla, the difference in incisor crowding between Tanzanian and Finnish children was significant only at ES1 and ES3. For the mandible, incisor crowding occurred more often among Finnish children with neutral occlusion than among Tanzanian children.

Distal molar occlusion occurred clearly less often among Tanzanian children than among Finns (Table 5). In both ethnic groups, the proportion of subjects with a distal molar occlusion was highest at ES2. At ES3 the difference for distal molar occlusion between the two ethnic groups was not significant. None of the Finnish children had a mesial molar occlusion, while among Tanzanian children it was found as early as ES0. The overall effects of ethnicity and emergence stage (P < 0.0001) for distal occlusion were statistically significant.

For anterior crossbite, no significant difference was found between the two ethnic groups (Table 6). An increased overjet was less prevalent among Tanzanian

Table 2 Prevalence (percentage) and 95 per cent confidence intervals (CI) of malocclusion among Tanzanian and Finnishchildren according to emergence stages of the permanent dentition.

| Emergence stage | Tanzanian | S | | Finns | P-value* | | |
|-----------------|-----------|------|---------|-------|----------|---------|--------|
| | п | % | 95% CI | п | % | 95% CI | |
| ES0 | 197 | 19.8 | (14–26) | 49 | 38.8 | (25–54) | 0.009 |
| ES1 | 207 | 41.1 | (33–47) | 271 | 61.0 | (47–66) | 0.0001 |
| ES2 | 64 | 51.0 | (37–63) | 111 | 77.3 | (68-85) | 0.0006 |
| ES3 | 189 | 38.1 | (31–45) | 275 | 76.4 | (58-82) | 0.0001 |
| ES4 | 212 | 47.2 | (43–57) | _ | - | | _ |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84).

*Tanzanians versus Finns.

The overall effects of ethnicity and emergence stage were statistically significant (P < 0.0001 and P < 0.0001, respectively).

Table 3 Prevalence (percentage) and 95 per cent confidence intervals (CI) of neutral occlusion among Tanzanian and Finnish children according to emergence stages of the permanent dentition.

| Emergence stage | Tanzanian | S | | Finns | Finns | | | | | |
|-----------------|-----------|------|---------|-------|-------|---------|-------|--|--|--|
| | п | % | 95% CI | n | % | 95% CI | | | | |
| ES0 | 197 | 91.3 | (86–95) | 49 | 81.6 | (68–91) | NS | | | |
| ES1 | 207 | 87.0 | (82–91) | 271 | 75.3 | (70-80) | 0.002 | | | |
| ES2 | 64 | 82.8 | (71–91) | 111 | 62.7 | (53–72) | 0.007 | | | |
| ES3 | 189 | 82.5 | (76–88) | 275 | 80.7 | (75–86) | NS | | | |
| ES4 | 212 | 83.0 | (78–87) | _ | _ | _ / | _ | | | |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84).

*Tanzanians versus Finns.

NS, not significant.

The overall effects of ethnicity and emergence stage were statistically significant (P < 0.0001 and P < 0.001, respectively).

| 255 |
|-----|
| |

| Emergence stage | Maxi | illary ir | ncisor crowdi | ng | | | P-value* | Man | ling | P-value* | | |
|-----------------|-----------|-----------|---------------|-------|---------|--------------|----------|-----------|------------|----------|-------------|--------|
| | Tanzanian | | | Finni | Finnish | | | Tanzanian | | Finnish | | |
| | n | % | 95% CI | п | % | 95% CI | | % | 95% CI | % | 95% CI | |
| ES0 | 179 | 0 | (0-2.0) | 40 | 7.5 | (1.6 - 20.4) | 0.006 | 0.6 | (0-3.1) | 10.0 | (2.8–23.7) | 0.004 |
| ES1 | 180 | 4.4 | (1.9-8.6) | 204 | 7.4 | (4.3–12.1) | 0.326 | 5.6 | (2.7-10.0) | 24.5 | (18.7–31.1) | 0.0001 |
| ES2 | 53 | 11.3 | (4.3 - 23.0) | 69 | 15.9 | (8.2–26.7) | 0.641 | 2.0 | (0-10.1) | 29.0 | (18.7–41.2) | 0.0002 |
| ES3 | 156 | 0.6 | (0-3.4) | 222 | 14.4 | (9.5–19.6) | 0.0001 | 1.9 | (0.4-5.4) | 31.1 | (23.8–36.9) | 0.0001 |
| ES4 | 176 | 2.3 | (0.6–5.9) | _ | - | - | NA | 4.0 | (1.9–8.6) | - | - | NA |

 Table 4
 Prevalence (percentage) and 95 per cent confidence intervals (CI) of incisor crowding in Tanzanian and Finnish children with neutral molar occlusion according to emergence stages of the permanent dentition.

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84). *Tanzanians versus Finns. NA, not applicable.

Table 5 Prevalence (percentage) and 95 per cent confidence intervals (CI) of distal and mesial occlusion among Tanzanian and Finnish children according to emergence stages of the permanent dentition.

| Emergence stage | Dista | al occlu | sion | | | | P-value* | Mesi | P-value* | | | |
|-------------------|------------------|--------------------|----------------------------|------------------|----------------------|------------------------------|---------------------------|-------------------|---------------------------|---|-------------------------------|--------------------|
| | Tanzanians | | | Finns | | | Tanzanians | | Finns | | | |
| | n | % | 95% CI | n | % | 95% CI | | % | 95% CI | % | 95% CI | |
| ES0 ES1 ES2 | 197 207 64 | 3.1 7.5 15.6 | (1-6) (4-12) (8-27) | 49 271 111 | 18.4 24.4 37.8 | (9-32) (20-30) (29-48) | 0.0003 0.0001 0.003 | 5.6 5.8 1.6 | (3-10) (3-10) (0-8) | $\begin{array}{c} 0\\ 0\\ 0\end{array}$ | (0-7.3) (0-1.2) (0-3.3) | NS 0.0002 NS |
| ES3 ES4 | 189 212 | 12.2 11.8 | (8-17) (8-17) (8-17) | 275 | 19.3 - | (14-24) | NS - | 5.3 5.2 | (3-9) (3-9) | 0 - | (0-1.2) | 0.0004 |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84). *Tanzanians versus Finns.

NS, not significant.

The overall effects of ethnicity and emergence stage for distal occlusion were statistically significant (P < 0.0001 and P < 0.0001, respectively).

Table 6 Prevalence (percentage) and 95 per cent confidence intervals (CI) of anterior crossbite and overjet greater than5 mm among Tanzanian and Finnish children according to emergence stages of the permanent dentition.

| Emergence stage | Ante | erior cr | ossbite | | | | P-value* | Overjet greater than 5 mm | | | | | | P-value* |
|---------------------------------|--------------------------------|---------------------------------|---|------------------------------|-------------------------------|---|---------------------|--------------------------------|------------------------------------|--|-------------------------|-----------------------------|--|--------------------------------------|
| | Tanzanians | | | Finn | s | | | Tanzanians | | | Finns | | | |
| | n | % | 95% CI | n | % | 95% CI | | n | % | 95% CI | n | % | 95% CI | |
| ES0 ES1 ES2 ES3 ES4 | 197 207 64 189 212 | 3.0 5.3 3.1 3.7 1.4 | $(1-6) \\ (3-10) \\ (0-11) \\ (2-7) \\ (0-4)$ | 49 271 111 275 - | 6.1 4.4 4.5 3.3 - | (1–17) (2–7) (2–10) (2–6) – | NS NS NS - | 188 175 64 189 212 | 2.7 6.9 14.1 12.2 19.3 | (1-6) (4-11) (7-25) (8-17) (14-26) | 46 226 109 273 | 4.3 22.6 40.4 32.6 | (1–15) (16–29) (31–50) (27–38) – | NS 0.0001 0.001 0.0001 - |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84). *Tanzanians versus Finns

NS, not significant.

The overall effects of ethnicity and emergence stage for overjet greater than 5 mm were statistically significant (P < 0.0001 and P < 0.0001, respectively).

than Finnish children, being highest at ES4 for Tanzanians and ES2 for Finns. The proportion of children with an increased overjet was larger with emergence stage but this declined. The overall effects of ethnicity and emergence stage (P < 0.0001) were statistically significant.

The mean values for overjet and overbite for the Tanzanian and Finnish children according to emergence stage of the permanent dentition are shown in Table 7. Tanzanian children had a significantly smaller overjet than their Finnish counterparts. Regarding the frequency of overjet in millimetres (Figure 1), a larger proportion of Finnish children had an overjet greater than 2 mm. The overall effects of ethnicity and emergence stage were statistically significant. In Tanzanian children, overjet increased with emergence stage of the permanent dentition, while among Finns it increased from ES0 to ES2 and thereafter declined. The overall effects of ethnicity (P < 0.0005) and emergence stage (P < 0.005) were statistically significant.

Table 7 Mean values of overjet and overbite (mm) in Tanzanian and Finnish children according to emergence stages of thepermanent dentition.

| Emergence stage | Over | jet (mm) | | | P-value* | Over | P-value* | | | |
|-----------------|-------|-----------------|-------|-----------------|----------|-------|-----------------|-------|-----------------|--------|
| | Tanza | anians | Finns | 5 | | Tanza | anians | Finns | 5 | |
| | n | Mean ± SD | n | Mean ± SD | | n | Mean ± SD | n | Mean ± SD | |
| ES0 | 188 | 1.96 ± 1.51 | 46 | 2.48 ± 1.49 | 0.04 | 188 | 1.47 ± 1.74 | 46 | 1.80 ± 1.61 | 0.24 |
| ES1 | 175 | 1.98 ± 1.85 | 226 | 3.52 ± 1.73 | 0.0001 | 168 | 0.91 ± 1.95 | 219 | 2.26 ± 1.65 | 0.0001 |
| ES2 | 64 | 2.88 ± 1.49 | 109 | 4.27 ± 1.87 | 0.0001 | 64 | 0.95 ± 1.68 | 109 | 2.99 ± 1.76 | 0.0001 |
| ES3 | 189 | 2.99 ± 1.47 | 273 | 3.96 ± 1.59 | 0.0001 | 189 | 1.46 ± 1.65 | 273 | 3.34 ± 1.65 | 0.0001 |
| ES4 | 212 | 3.24 ± 1.79 | - | - | - | 212 | 0.97 ± 2.08 | - | - | - |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84).

*Tanzanians versus Finns.

SD, standard deviation.

The overall effects of ethnicity and emergence stage for overjet were statistically significant (P < 0.0005 and P < 0.0005, respectively). The overall effects of gender, ethnicity and emergence stage for overbite were statistically significant (P = 0.003, P < 0.0005 and P < 0.0005, respectively).

There was a significant difference between boys and girls among Tanzanians at ES0 (P = 0.014) and among Finns at ES1 (P = 0.03) and ES3 (P = 0.04).



Figure 1 Distribution of subjects with different degrees of overjet in millimetres among Tanzanian (869) and Finnish (706) children aged 3.5–16 years.

Whereas in Tanzanian children no consistent pattern for overbite was found according to emergence stage, in Finns overbite increased from ES0 to ES3. The overall effects of gender (P = 0.003), ethnicity (P < 0.0005) and emergence stage (P < 0.0005) were statistically significant. Girls had a larger mean value than boys. Significant differences between boys and girls among Tanzanians at ES0 (P = 0.014) and among Finns at ES1 (P = 0.03) and ES3 (P = 0.04) were also found.

The prevalence and 95 per cent confidence intervals of subjects with deep bite and anterior open bite are presented in Table 8. Among Tanzanians, deep bite was rare compared with the Finns. In Finnish children, a clear increase with emergence stage was seen. The overall effects of gender (P < 0.01), ethnicity (P < 0.0001) and emergence stage (P < 0.0001) were statistically significant. Girls had a deep bite more often than boys. With regard to anterior open bite, Tanzanians presented this clinical feature more often than Finnish children and the overall effects of ethnicity (P < 0.0001) and emergence stage (P = 0.02) were statistically significant.

Lateral open bite and transverse occlusal anomalies (data not shown) were rare. However, Tanzanian children had a lateral open bite less often than Finns; 0-4 and 1-5 per cent, respectively. Whereas a lateral crossbite occurred in 1-7 per cent of Tanzanians and 4-10 per cent of Finns, a scissors bite occurred in 0-4 per cent of the Tanzanian and in 0-3 per cent of the Finnish children. The overall effect of emergence stage (P = 0.04) for lateral crossbite was significant.

Discussion

In the present cross-sectional study, occlusal characteristics and anomalies were evaluated in two groups of Tanzanian and Finnish children aged between 3.5 and 16 years. A method considering four categories of emerging permanent teeth into the oral cavity was employed for data collection (Pahkala et al., 1991). Thereafter, emergence categories of individual permanent teeth (minimum = 0, maximum = 84) were used to determine the five emergence stages (ES0-ES4) of the permanent dentition. The emergence stages were useful for comparing the children from the two ethnic groups at the communitybased epidemiological study level without the use of radiographs. Use of the emergence stages of the permanent dentition enables valid comparisons of dental development in children regardless of differences between dental and chronological age (Davidson and Rodd, 2001). The variation in timing of tooth emergence within each age cohort is so wide that when evaluating the development of occlusion and/or malocclusion, the developmental stages of the permanent dentition are much more important than chronological age.

Two ethnic groups were studied, namely Bantu children in Tanzania and Finnish children in Finland. In Tanzania, cluster sampling was used to obtain the sample from schools, generally with children from a wide range of social backgrounds. Cluster sampling of subjects may have an influence on the representativeness of the sample, but a large number of schools was selected to minimize this effect. For a descriptive study, there is no reason to doubt that the findings could not

Table 8 Percentages and 95 per cent confidence intervals (CI) of subjects with deep bite and anterior open bite in Tanzanianand Finnish children according to emergence stages of the permanent dentition.

| Emergence stage | Deep | o bite g | greater thar | n 5 mn | 1 | | P-value* | Anterior open bite | | | | | | P-value* |
|-----------------|------------|----------|--------------|--------|------|---------|----------|--------------------|------|---------|-------|-----|--------|----------|
| | Tanzanians | | | Finn | s | | | Tanzanians | | | Finns | | | |
| | n | % | 95% CI | n | % | 95% CI | | n | % | 95% CI | n | % | 95% CI | |
| ES0 | 188 | 0.5 | (0-3) | 46 | 4.3 | (1-15) | NS | 197 | 6.6 | (4–11) | 49 | 6.1 | (1–17) | NS |
| ES1 | 168 | 1.2 | (0-4) | 219 | 7.3 | (4–12) | 0.01 | 207 | 14.0 | (10-20) | 271 | 2.6 | (1-5) | 0.0001 |
| ES2 | 64 | 1.6 | (0-8) | 109 | 22.0 | (15-31) | 0.0005 | 64 | 18.8 | (10-30) | 111 | 3.6 | (0-8) | 0.002 |
| ES3 | 189 | 2.1 | (0-5) | 273 | 20.9 | (16–26) | 0.0001 | 189 | 6.9 | (4–11) | 275 | 2.2 | (1-5) | 0.02 |
| ES4 | 212 | 0.5 | (0–3) | - | - | _ | - | 212 | 12.7 | (8–18) | - | - | _ | |

ES0, complete primary dentition only (ES = 0); ES1, incomplete first phase of the mixed dentition ($1 \le ES \le 35$); ES2, complete first phase of the mixed dentition (ES = 36); ES3, incomplete second phase of the mixed dentition ($37 \le ES \le 83$); ES4, complete permanent dentition (ES = 84).

*Tanzanians versus Finns.

NS, not significant.

The overall effect of gender was statistically significant (P < 0.01).

The overall effects of ethnicity and emergence stage for deep bite greater than 5 mm were statistically significant (P < 0.0001 and P < 0.0001, respectively).

The overall effects of ethnicity and emergence stage for anterior open bite were statistically significant

(P < 0.0001 and P = 0.02, respectively).

be applied to the whole Bantu child population in Dar es Salaam. In Tanzania, the Bantu ethnic group is the majority, comprising 95 per cent of the whole population. For the Finns, the population in the rural areas is very homogeneous and, therefore, the Juuka municipality sample can be considered to represent the whole population. None of the Tanzanian children had received any orthodontic treatment. The Finnish children in ES4 were not included in the analyses as it could not be excluded that some children had received orthodontic treatment which could influence the comparison.

Some community-based epidemiological studies on malocclusion in Tanzania have been published (Kerosuo et al., 1988, 1991; Mugonzibwa et al., 1990; Kerosuo, 1990; Mugonzibwa, 1992), but the samples in these studies were mixed in ethnic origin. Furthermore, not all occlusal anomalies in the sagittal, vertical and transverse planes were reported. With regard to comparative studies between Tanzanian and Finnish children (Kerosuo, 1990; Kerosuo et al., 1991), chronological age had been used instead of emergence stages of the permanent dentition to compare subjects. Permanent teeth in African and African-American children emerge earlier into the oral cavity compared with Caucasians of the same age (Garn et al., 1973; Richardson et al., 1975; Lavelle, 1976; Kerosuo, 1990). A recent study (Davidson and Rodd, 2001) reported that the difference between dental and chronological age was significantly greater among Somali children (1.01 years for boys, 1.22 years for girls) compared with their Caucasian counterparts (0.19 years for boys, 0.52 years for girls). These findings underline the importance of considering the stage of emergence of permanent teeth into the oral cavity in community-based epidemiological studies on occlusal characteristics and anomalies.

The lower prevalence of occlusal anomalies in Tanzanian children is in agreement with previous studies on occlusion of early, late mixed and permanent dentitions of children from comparable Tanzanian and Finnish Caucasian populations (Kerosuo, 1990; Kerosuo *et al.*, 1991). African children, whether of African or African-American origin, have consistently been reported to have a Class I molar occlusion more often than their Caucasian counterparts, and correspondingly show less malocclusions.

Distal molar occlusion as well as an increased overjet were found significantly less often among Tanzanians compared with Finns. Tanzanians also had a smaller mean overjet value than Finns. These findings are parallel to previously reported findings between Tanzanian and African-American and Caucasian subjects (Kelly and Harvey, 1976; Lavelle, 1976; McLain and Proffit, 1985; Kerosuo, 1990; Kerosuo *et al.*, 1991), but during the second transitional phase (ES3) there was no difference in the prevalence of distal occlusion between the two ethnic groups, while no comparison could be carried out at ES4. Although mesial molar occlusion occurred significantly more often among Tanzanians as compared with Finns, it did not correspond to the anterior crossbite proportions, implying that not all children with mesial molar occlusion necessarily had an anterior crossbite. On the other hand, as mesial occlusion has been reported to develop as late as 15 years of age (Laine and Hausen, 1983), it is likely to be rare and not all malocclusion features associated with it may appear by the age of 11 years as in the studied sample. The present and previous results partly confirm the basic structural differences in the sagittal skeletal relationship (Enlow *et al.*, 1982) between Tanzanians and Finns.

In Tanzanian children, incisor crowding was not a significant problem when compared with the Finnish sample. However, not all children with neutral occlusion were malocclusion free. Incisor crowding occurred in 0–31 per cent of the children with neutral occlusion in different emergence stages of the permanent dentition. In Tanzanian children, incisor crowding was most frequent in the maxilla at ES2, occurring in 11 per cent of the subjects. These findings suggest that most maxillary incisor crowding in Tanzanian children resolves during the later developmental stages.

Comparing the present findings with the previous Tanzanian reports (Kerosuo et al., 1988, 1991; Mugonzibwa et al., 1990; Kerosuo, 1990; Mugonzibwa, 1992), the Tanzanian Bantu children had a slightly higher prevalence of distal molar occlusion. The results for mesial molar occlusion were in agreement with some previous Tanzanian reports (Mugonzibwa et al., 1990; Mugonzibwa, 1992). As the present sample comprised only Bantu ethnic subjects, this might have increased the degree of homogeneity as compared with previous Tanzanian samples comprising multiple tribes/ethnic groups. This fact may be the source of the differences observed between the present and previous Tanzanian findings. Also, results showing lower frequencies of mesial molar occlusion for Tanzanian and African children than found in the present study have been reported (Houpt et al., 1967; Aggarwal and Odusanya, 1985; Kerosuo et al., 1988, 1991; Kerosuo, 1990). However, the study methods, age ranges and data presentations among several African reports vary considerably, which may have partly influenced the differences.

With regard to the Finnish subjects, distal molar occlusion was more prevalent compared with previous Finnish findings (Laine and Hausen, 1983; Jämsä *et al.*, 1988). In contrast to mesial occlusion, distal occlusion becomes less frequent in the later stages of facial growth. The present results also show this tendency, which continues beyond the age of 11 years (Laine, 1984). The variation in occlusal anomalies in the sagittal plane even within the same population may partly reflect secular trends in the development of occlusal anomalies or the influence of environmental factors.

Tanzanian children had a deep bite with a smaller degree of overbite less often, but an anterior open bite more often than Finns, in agreement with previous studies (Kelly and Harvey, 1977; McLain and Proffit, 1985; Kerosuo *et al.*, 1991). Bacon *et al.* (1983) related the differences in sagittal and vertical occlusion between African Bantu and Caucasian ethnic groups to the more proclined position of the incisors and larger anterior face height of the Bantus. African-Americans are also reported to have more procumbent and protrusive maxillary and mandibular incisors (Alexander and Hitchcock, 1978). The differences in vertical occlusal development between the two ethnic groups may, therefore, partly reflect skeletal, muscular or genetic differences (Bacon *et al.*, 1983).

Considering the transverse occlusal traits, there was no significant difference between the two ethnic groups. This finding is contrary to previous studies (Infante, 1975; McLain and Proffit, 1985; Kerosuo, 1990; Kerosuo *et al.*, 1991) which reported that lateral crossbite occurred more often among Caucasians compared with African and African-American children. The contrast may be attributed to the fact that in this study the comparison was made between children with the same emergence stage of the permanent dentition instead of age. On the other hand, orthodontic treatment might have been carried out in the Finnish subjects, as lateral crossbite is considered one of the most important occlusal anomalies to treat at an early age, even at 3 years if the child is co-operative (Tschill *et al.*, 1997).

A gender difference was observed for overbite, with girls having a larger mean value than boys and more girls having a deep bite than boys. In the present study, no significant gender difference was found for other occlusal traits.

Among the Finns there was a tendency for the overjet to increase with advancing emergence stage until ES2, but to decrease towards ES3, in agreement with a recent Colombian investigation using almost similar methods (Thilander et al., 2001). Heikinheimo et al. (1982), in a longitudinal study among Swedish children, also found that maxillary overjet increased with age. Like the Colombian children, there was a tendency for distal occlusion to increase steadily from ES0 to ES2, the occurrence of distal occlusion and also increased overjet for Finns being highest at ES2. However, a distal occlusion at ES2 can still change to a neutral occlusion if there is a flush terminal plane of the primary second molars (Thilander and Rönning, 1995). In the case of overbite, the mean value increased steadily from ES0 to ES3 in Finnish children. This is in agreement with a longitudinal study showing that overbite increases with age until 12 years, after which it decreases to adulthood (Bergersen, 1988). No clear trend could be seen in changes in the prevalence of lateral crossbite with advancing emergence of the permanent dentition.

While some investigators suggest that malocclusion is predominantly genetically determined (Chung et al., 1971; Chung and Niswander, 1975; Smith and Bailit, 1977; Saunders et al., 1980; Nakasima et al., 1982; Peck et al., 1998), others have supported the importance of environmental influence (Niswander, 1966; Lombardi and Bailit, 1972; Corruccini, 1984). There are researchers who support the concept of polygenic inheritance, implying that both genetic factors and environmental influences have a role to play in the aetiology of malocclusions (Harris and Smith, 1980, 1982). However, Lobb (1987) reported the dominance of environmental factors over genetic influences among monozygous and dizygous twins in the dental/alveolar area. Whether the observed ethnic differences in the sagittal, vertical and transverse occlusal traits found in this and other studies between Tanzanian and Finnish children reflect the influence of either genetic or environmental factors cannot be determined by this study.

Conclusions

Most of the classic malocclusions occur among Tanzanian children, but the prevalence differs from that in other parts of the world. Significant differences between Tanzanians and Finns were found for malocclusion, neutral and distal molar occlusion, overjet greater than 5 mm, deep bite and anterior open bite. Thus, in estimating orthodontic treatment need in Tanzanian and Finnish children, the focus of treatment will differ between the two populations. In both ethnic groups, the occlusion clearly changes with advancing emergence of the dentition and this needs to be considered in treatment planning.

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