



Time of mineralization of permanent teeth in children and adolescents in Gaborone, Botswana



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ABSTRACT

The mineralization sequence of permanent dentition can be used to assess the stage of development and age of individuals. The most commonly used methods are based on the assessment of developmental stages of target groups of teeth on one side of the lower jaw. When compared with the rest of the world, fewer studies have been done on dental age in Sub-Saharan Africa, particularly in the region of Southern Africa.

The aim of this study was to determine the chronology of mineralization of permanent teeth by the evaluation of developmental stages according to the Demirjian's method from 1973 and to evaluate dental age by using sex-specific self-weighted scores for dental stages and 50th percentile conversion tables of total maturity scores of seven mandibular teeth. We used a sample of panoramic radiographs (OPTs) of black African children and adolescents from the city of Gaborone, Botswana, with the aim of forming an appropriate sample to evaluate the development of the teeth in this socio-geographic environment.

The final sample consisted of 1760 OPTs (807 males and 953 females) of individuals aged 6–23 years. The developmental stages of the all permanent teeth in the left side of the maxilla and the mandible were evaluated.

Comparing the maxilla and the mandible, we found similar development within different stages for most of the teeth. In comparison to the average age at each stage of development, including the third molars between males and females, it is evident that females are slightly faster in developing permanent teeth, but without statistical significance for most of the developmental stages.

Applying 50th percentile conversion tables for calculating the dental age for the first seven mandibular teeth, 616 OPTs of the children (299 males and 317 females), aged 6.08–16.80 years, were evaluated and their dental age was calculated. Mean dental age was overestimated in comparison to chronological age by 1.25 ± 1.11 years and 0.72 ± 1.02 years for males and females, respectively ($p < 0.001$).

These findings indicate that Demirjian's method from 1973 is not suitable for routine use and that there is a need for establishing specific standards for Botswana children of black African origin for dental age estimation.

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1. Introduction

Amongst many anatomical systems, teeth provide abundant information related to growth and development of the whole body. They change in two sequences, first as a deciduous and

then as permanent dentition, so that these changes cover the time span from birth until the end of adolescence. The possibility of insight into these changes, either by clinical examination or certain radiographic procedures, creates the opportunity to estimate the biological age of a person by analyzing their teeth. When compared to other body systems in children, in particular the skeletal system, which can also be evaluated by radiography, the development of teeth is considered to be more reliable (Feijoo et al., 2012; Krailassiri et al., 2002; Uysal et al., 2004). Most of the studies on dental development evaluated dental age (DA) by

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using specific radiographic methods on a total number of selected teeth. These methods analyze the degree of tooth mineralization attained or the size of open apices on radiographic records, mostly panoramic (OPTs) (Cameriere et al., 2006a; Demirjian et al., 1973; Moorrees et al., 1963; Nolla, 1960). The most common method for DA estimation in children was introduced by Demirjian et al. in 1973 (Demirjian and Goldstein, 1976; Demirjian et al., 1973). The authors divided single and multi-rooted tooth development into eight formation stages. Formation stages were also illustrated by diagrams and radiographic pictures of incisors, canines, bicuspids and molars (Demirjian et al., 1973). In the majority of studies of dental development, mandibular teeth were predominantly studied, because of smaller distortion, when compared to maxillary teeth which have greater tendency of malposition, rotation or crowding (Demirjian and Goldstein, 1976; Demirjian et al., 1973; Haavikko, 1974; Liversidge, 2011, 2012). However, several recent studies in different populations studied permanent teeth in both jaws (Feijoo et al., 2012; Lee et al., 2008).

After initially studying 14 teeth from the upper and the lower left quadrants, only the system using seven teeth from the left side was further investigated, because of the high degree of correlation between the upper and lower jaw and the single side system that gives almost the same estimation as the one using all 14 teeth (Demirjian et al., 1973). Then, each of formation stages of the seven permanent teeth from the mandible were given a specific score of development, similarly to the approach by Tanner, Whitehouse and Healy, who scored development according to each bone of the hand and wrist (Tanner et al., 1962). The scores on all the seven teeth are then calculated together to give a total maturity score. Separate tables of 50th percentile dental maturity score based on French–Canadian males and females were used to convert total dental maturity scores into dental age (Demirjian et al., 1973). The Demirjian method and tables have been extensively used in different populations. Some studies suggested that French–Canadian standards were appropriate but most studies demonstrated that population-specific standards were necessary because of the difference between calculated dental age and chronological age (CA) (Cunha et al., 2009; Feijoo et al., 2012; Galić et al., 2010; Nyström et al., 1986; Sen Tunc and Koyuturk, 2008; Willems et al., 2001). According to our literature search, there are no previous studies on dental development in Botswana's children and adolescents of black African origin.

The aim of this study has been to explain the age within Demirjian stages of dental development of all permanent teeth from the left side on a sample of Botswana's children and adolescents of African origin and to build a reference database for studying dental development of subjects of specific ethnical and geographic backgrounds.

2. Materials and methods

In a cross-sectional study, we investigated OPT radiographs of children and adolescents aged 6–23 years who visited two private orthodontic practices from 2001 to 2015, located in the city of Gaborone, in the Republic of Botswana. The study was conducted in accordance to the ethical standards laid down by the Declaration of Helsinki (World Medical Association, 2013). Approval for the study was granted by the HRDC (Human Research and Development Committee) of the Ministry of Health in Botswana. All available OPTs from the sample were evaluated and only black African subjects up to 23 years of age were included in the study because of few available OPTs of Caucasians and Asians. Also, we found no evidence of the development of permanent teeth in older individuals. OPTs without accompanying subject's full dental records, lack of birth date and date when the OPTs were taken, as well as those OPTs

Table 1

Chronological age group distribution of panoramic radiographs of black African children from the city of Gaborone, in the Republic of Botswana.

Age group	Males	Females	Total
6.0–6.9	22	21	43
7.0–7.9	23	20	43
8.0–8.9	26	22	48
9.0–9.9	21	29	50
10.0–10.9	27	32	59
11.0–11.9	50	50	100
12.0–12.9	56	67	123
13.0–13.9	49	59	108
14.0–14.9	59	56	115
15.0–15.9	48	69	117
16.0–16.9	69	71	140
17.0–17.9	53	68	121
18.0–18.9	45	69	114
19.0–19.9	50	74	124
20.0–20.9	47	57	104
21.0–21.9	60	64	124
22.0–22.9	55	64	119
22.0–22.9	47	61	108
Total	807	953	1760

of children with proven hereditary or systematic illnesses, malnutrition, severe destruction, extraction, or hypodontia of permanent teeth, and where the third molars were missing, were excluded from the study. In total, 1760 OPTs, 807 males and 953 females, were evaluated (Table 1).

The chronological age (CA) of children was calculated as the difference between the date the OPT was taken and birth date (rounded off to two decimal places), with age groups based on one year increments. The developmental stages, alphabetically abbreviated (A–H) according to the method of Demirjian et al. (Demirjian et al., 1973) of all permanent teeth in the left side of the maxilla and mandible, were evaluated by the first author (JC). Additionally, the crypt stage of the third molars, abbreviated as zero (0), was also evaluated. The average age within each stage in all permanent teeth from the left side was calculated separately for males and females. An independent sample *t*-test was used to compare the means of chronological age across developmental stages between the antagonistic teeth, as well as between sexes. The next step was to evaluate the usefulness of the original French–Canadian self-weighted scores for dental stages and tables for conversion to dental age in children as described by Demirjian et al. (1973). All children who had not completed mineralization of at least one of the seven permanent teeth from the mandible, excluding third molars, were evaluated and dental age (DA) was calculated. More specifically, stages of the seven left mandibular teeth were converted to specific values for each stage by using sex-specific tables of self-weighted scores for dental stages from Demirjian et al. (1973). These self-weighted, sex specific scores, for each tooth were based on the mathematical balancing of tooth development across stages on a French–Canadian sample of 2928 males and females age 2–20 years (Demirjian et al., 1973). The values of scores of all seven teeth were summed as dental total maturity scores and expressed as percentages. Then the 50th percentile dental maturity score was converted to dental age by using sex-specific tables from Demirjian et al. (1973).

In total, 616 OPTs of children (317 females) aged 6.08–16.80 years were included in the dental age estimation using the Demirjian 1973 method. Paired sample *t*-tests were used to compare DA and CA. Mean absolute error (MAE) of time distance from real age of children was also calculated. Evaluation of 100 randomly selected OPTs was conducted by JC for the second time, 2 months following initial evaluation, as well as by IG. Based on these 100 OPTs, intra- and inter-rater agreement of mineralization stages were calculated using kappa scores and intra- and inter-rater agreement of dental age by Demirjian et al. (1973) was calculated

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