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A retrospective comparison of dental and skeletal ages between African American, Caucasian, and Hispanic subjects

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Abstract:

OBJECTIVE: To compare dental and skeletal ages among African American (AA), Caucasian (C) and Hispanic (H) subjects (chronological ages 9 to 15-years).

MATERIAL AND METHODS: A total of 168 subjects (9 to 15 years old) were equally divided into AA, C, and H groups, with an equal number of males and females. Each group was divided equally into 7 chronological age-groups, ranging from 9 to 15 years. Dental age was determined from panoramic radiographs as primary, early mixed, late mixed, or permanent dentition (scored as 1-4). Skeletal age was calculated from hand-wrist radiographs using Fishman's Skeletal Maturation Index (SMI 1-11). One-way analysis of variance and Tukey's test were used to compare skeletal and dental ages among AA, C and H subjects; and AA, C and H subjects in each chronological age-group. The two-sample t-test was used to compare SMI and dental age among females and males.

RESULTS: Skeletal and dental age were not significantly different between AA, C and H subjects. Mean SMI was higher in females than males; and there were no significant gender differences regarding dental age. Mean SMI and dental age were significantly different among AA, C and H subjects in the 12-year-old and 11-year-old age groups, respectively.

CONCLUSIONS: Dental and skeletal maturation are fairly similar among AA, C and H subjects (aged 9 to 15 years).

Keywords:

African Americans, Caucasians, dental age, Hispanics, skeletal age

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Introduction

Changes in chronological age, sexual maturation, dental development, and skeletal age have been used to assess growth.^[1-4] The timing of these changes varies based on an individual's biological clock;^[3] however, various systemic and pathologic conditions such as cerebral palsy,^[5] Down syndrome,^[5] multiple osteochondromas,^[6] and disorders of retinoic acid metabolism^[7]

may also influence the timing of skeletal and dental maturation. Maturation and growth have been significantly correlated with skeletal maturation, as indicated by the hand-wrist radiograph.^[3,8,9] Furthermore, it has been shown that dental age estimation is equally reliable to skeletal age estimation, and both of these variables have been correlated with growth.^[10]

The dentition changes during maturation^[2] and various stages of dental age have been described, including primary, early mixed, late mixed, and permanent dentition.^[11]

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Specifically, the primary stage of dentition includes only primary teeth; and is usually observed before the age of six. During early mixed dentition, the permanent incisors and first molars have erupted in addition to the primary teeth. Late mixed dentition refers to a stage when more permanent teeth have erupted, but not yet all permanent teeth, which would indicate the permanent dentition stage. The skeletal maturation index (SMI),^[4] and cervical vertebral maturation (CVM) index^[12] have been used to assess skeletal age based on hand-wrist and lateral cephalometric radiographs, respectively. Studies^[8,13] have shown that both hand-wrist and cervical analysis are highly correlated and equally accurate in determining skeletal growth.

Studies^[14-17] have assessed the influence of race and/or ethnicity on the timing and rate of growth. For instance, one study^[15] identified racial differences in the CVM stages in Hispanics (H) compared with Whites (W) and African Americans (AA). Conversely, Oh *et al.*^[16] did not identify significant differences in the skeletal maturation stage between Danish and Korean children. Maki *et al.*^[17] reported that dental development was more advanced in W than Chinese or Japanese children, whereas Elamin *et al.*^[18] did not report ethnic differences in dental development. Based on these findings, it appears there is a controversy in indexed literature regarding the influence of race and/or ethnicity on the timing of dental and skeletal maturation.

With this background, the primary aim of this retrospective study was to compare dental and skeletal ages among AA, C and H subjects between the chronological ages of 9 and 15 years. Secondary aims were to compare dental and skeletal ages between male and female subjects in each group (AA, C and H); and to compare dental and skeletal ages in each chronological age group (9, 10, 11, 12, 13, 14 and 15 years) among AA, C, and H subjects.

Methods

This study was exempt after review by an Institutional Review Board (no. RSRB00072300) at Eastman Institute for Oral Health (EIOH), University of Rochester, Rochester, New York, under category 45 CFR 46.101; due its retrospective nature and the collection of existing de-identified data.

A total of 168 subjects (chronological ages 9 to 15 years old) were equally divided into C ($n = 56$), AA ($n = 56$), and H ($n = 56$) groups. Each group had an equal number of male and female subjects, and was further divided into 7 chronological age-groups: 9, 10, 11, 12, 13, 14, and 15 years [total of 21 groups, eight patients each (four males, four females)]. Records were obtained from the

Orthodontic Department at EIOH database, through an electronic search between January 2009 and December 2013. Subjects were selected consecutively, and had consented to the use of their records for publication. Inclusion criteria were as follows: (a) subjects aged between 9 and 15 years; (b) no systemic diseases, syndromes or endocrine disorders; (c) subjects that were AA, C or H (self-reported and assessed through subjects' charts); and (d) all subjects had digital panoramic and hand-wrist radiographs available of high diagnostic quality. Subjects that were younger than 9 or older than 15 years, with systemic diseases, syndromes or endocrine disorders, with incomplete charts and with radiographs of poor diagnostic quality were excluded.

Digital panoramic and hand-wrist radiographs, taken from the same machine (Instrumentarium OP/OC100D, Milwaukee, WI) and of high diagnostic quality, were collected for each subject to assess dental and skeletal age, respectively. Dental age was defined as primary, early mixed, late mixed, or permanent (scored as 1-4, respectively);^[19,20] while, skeletal age was calculated using Fishman's SMI analysis [Figure 1].^[4] All measurements were conducted by the same investigator (MS); and measurements for 10 subjects were recalculated one week later by the same and a second investigator (SM) to assess intra- and interobserver reliabilities, respectively.

Statistical analysis

A power analysis showed that a minimal of 50 subjects in each group (AA, C and H) achieves 80% power to detect a difference of 1 in the SMI, with significance level set at 0.05.^[21] The concordance correlation coefficient (CCC) was used to measure the intra- and interobserver reliabilities. One-way analysis of variance (ANOVA) was used to compare the mean chronological, skeletal and dental ages among AA, C and H subjects. The two-sample t-test was used to compare mean SMI and dental age among female and male subjects for the total study sample, and AA, C, and H groups. The mean dental and skeletal ages were compared among AA, C and H

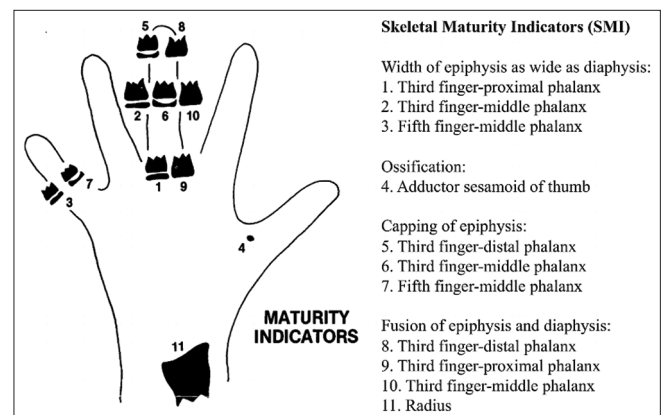


Figure 1: Diagram of skeletal maturity indicators (SMI)^[4]

subjects in each chronological age-group using ANOVA followed by Tukey’s test. Differences were considered significant when $P < 0.05$. All data were analyzed with SAS 9.2 software (SAS Institute Inc, Cary, NC).

Results

The intra- and interobserver reliabilities were high (CCC>0.95).

Maturation indicators among AA, C and H subjects

The mean ± standard deviation (sd) chronological age, SMI, and dental age of the total study sample ($n = 168$) were 12 ± 2.0 years, 6.3 ± 3.3 , and 3.6 ± 0.7 , respectively. The mean ± sd age in AA ($n = 56$), C ($n = 56$) and H ($n = 56$) subjects was 12 ± 2 years. The mean ± sd SMI in AA, C and H subjects was 6.5 ± 3.3 , 5.9 ± 3.3 and 6.6 ± 3.2 , respectively. There were no significant differences in the mean SMI ($P = 0.53$) among AA, C and H subjects. Twenty-five (5 AA, 9 C, 11 H), 26 (8 AA, 12 C, 6 H), and 117 (43 AA, 35 C, 39 H) subjects were in the early mixed (score 2), late mixed (score 3), and permanent (score 4) dentition, respectively. The mean ± sd dental age in AA, C and H subjects was 3.7 ± 0.6 , 3.5 ± 0.8 , and 3.5 ± 0.8 , respectively; and there was no significant difference in the mean dental age among groups (AA, C and H).

Maturation indicators among male and female subjects

In the total study sample, the mean ± sd SMI was 7.6 ± 3.0 in female ($n = 84$) and 5.0 ± 3.0 in male subjects ($n = 84$). The mean SMI was significantly higher in female than male subjects ($P < 0.0001$) for the total study sample. There was no significant difference in the mean dental age among the total female ($n = 84$) (3.6 ± 0.7) and male ($n = 84$) (3.5 ± 0.8) subjects ($P = 0.21$).

Gender differences in the mean SMI and dental age were also evaluated in each group (AA, C, and H). The mean SMI was significantly higher in female than male subjects in the AA ($P = 0.004$), C ($P = 0.005$) and H ($P = 0.0007$) groups. The mean dental age did not differ significantly between male and female subjects in the AA, C and H groups [Table 1].

Maturation indicators among AA, C and H chronological age-groups

The mean SMI was significantly different among AA, C and H subjects in the 12-year-old age-group ($P = 0.03$). Tukey’s test showed that mean SMI was significantly increased ($P = 0.04$) in H compared with C 12-year-old subjects, while differences were not significant among the other 12-year-old groups. There were no significant differences in the mean SMI among AA, C and H subjects

in the 9-, 10-, 11-, 13-, 14-, and 15-year-old chronological age-groups [Table 2].

The mean dental age was significantly different among AA, C and H subjects in the 11-year-old age-group ($P = 0.03$). Tukey’s test showed that mean dental age was significantly increased ($P = 0.03$) in AA compared with C 11-year-old subjects; and there were no significant differences among the other 11-year-old groups. There were no significant differences in the mean dental age among AA, C and H subjects in the 9-, 10-, 12-, 13-, 14-, and 15-year-old age-groups [Table 3].

Table 1: Comparison of SMI and dental age among AA, C and H male and female subjects

Race	Variable	Females			Males			P*
		n	Mean	SD	n	Mean	SD	
AA	SMI	28	7.8	3.1	28	5.3	3.1	0.004
	Dental age	28	3.8	0.5	28	3.6	0.7	0.21
C	SMI	28	7.1	3.1	28	4.7	3.1	0.005
	Dental age	28	3.4	0.8	28	3.5	0.7	0.73
H	SMI	28	8	2.8	28	5.2	3	0.0007
	Dental age	28	3.6	0.7	28	3.4	0.9	0.19
Total	SMI	84	7.6	3.0	84	5.0	3.0	<0.0001
	Dental age	84	3.6	0.7	84	3.5	0.8	0.21

SMI, skeletal maturation indicators; AA, African Americans; C, Caucasians; H, Hispanics; n, number of subjects; SD, standard deviation. *Two-sample t test. Boldface font indicates significant differences ($P < 0.05$)

Table 2: Comparison of skeletal age (SMI) among AA, C and H chronological age-groups

Chronological age-group	Descriptive statistics of skeletal age (SMI)			P*	
	Group	n	Mean		SD
9	AA	8	2.38	1.41	0.42
	C	8	2.38	1.77	
	H	8	3.25	1.28	
10	AA	8	4.13	1.89	0.76
	C	8	3.25	2.49	
	H	8	3.75	2.55	
11	AA	8	6.63	3.29	0.24
	C	8	4.13	2.23	
	H	8	5.00	3.12	
12	AA	8	5.50	2.45	0.03
	C	8	5.38 [†]	1.77	
	H	8	8.00 [†]	1.93	
13	AA	8	8.38	2.62	0.60
	C	8	7.13	2.47	
	H	8	7.38	2.62	
14	AA	8	8.50	2.73	0.63
	C	8	8.75	1.49	
	H	8	9.50	2.00	
15	AA	8	10.00	0.93	0.07
	C	8	10.50	0.76	
	H	8	9.13	1.55	

SMI, skeletal maturation indicators; AA, African Americans; C, Caucasians; H, Hispanics; n, number of subjects; SD, standard deviation. *One-way analysis of variance. Boldface font indicates significant group differences ($P < 0.05$). [†]Tukey’s test showed that mean SMI was significantly increased ($P = 0.04$) in H compared with C 12-year-old subjects

Table 3: Comparison of dental age among AA, C and H chronological age-groups

Chronological age-group	Descriptive statistics of dental age				P*
	Group	n	Mean	SD	
9	AA	8	2.88	0.83	0.13
	C	8	2.38	0.52	
	H	8	2.25	0.46	
10	AA	8	3.13	0.83	0.42
	C	8	2.88	0.64	
	H	8	2.63	0.74	
11	AA	8	4.00 [†]	0.00	0.03
	C	8	3.13 [†]	0.83	
	H	8	3.75	0.71	
12	AA	8	4.00	0.00	0.38
	C	8	3.88	0.35	
	H	8	4.00	0.00	
13	AA	8	3.88	0.35	0.61
	C	8	4.00	0.00	
	H	8	3.88	0.35	
14	AA	8	3.88	0.35	0.38
	C	8	4.00	0.00	
	H	8	4.00	0.00	
15	AA	8	4.00	0.00	1.00
	C	8	4.00	0.00	
	H	8	4.00	0.00	

AA, African Americans; C, Caucasians; H, Hispanics; n, number of subjects; SD, standard deviation. *One-way analysis of variance. Boldface font indicates significant group differences ($P < 0.05$). [†]Tukey's test showed that mean dental age was significantly increased ($P = 0.03$) in AA compared with C 11-year-old subjects

Discussion

The timing of orthodontic treatment initiation may significantly influence the treatment results, especially in subjects where growth modification is needed.^[22,23] For instance, it has been suggested that functional appliance therapy is most effective during or right after the peak in mandibular growth,^[22-24] whereas, facemask therapy is most effective in the primary or early mixed dentition.^[25,26] Various indicators including dental and skeletal age have been used to evaluate an individual's maturation stage.^[1-4] Studies^[14-17] have evaluated differences in maturation indices such as the CVM stages among various ethnic groups. However, there is a lack of consensus in indexed literature regarding the influence of race and/or ethnicity on dental and skeletal maturation. To the authors' knowledge, the present study is the first one to compare maturation stages, including SMI and dental age between AA, C and H subjects using hand-wrist and panoramic radiographs. The clinical implication of potential differences in the rate of maturation between different ethnic and racial groups is that modifications may be warranted in the timing of orthodontic treatment initiation. In this retrospective study, it was hypothesized that significant differences exist in the rate of dental and skeletal maturation among AA, C and H subjects aged between 9 to 15 years.

Based on the results of the present study, the research hypothesis is rejected; as significant differences in dental and skeletal age were not identified between AA, C and H subjects. Moreover, the present results showed that mean skeletal and dental ages are significantly different among AA, C and H subjects only in the 12-year-old and 11-year-old age-groups, respectively; and there are no significant differences among the other chronological age-groups assessed in this study. Based on these findings, no modifications are recommended in the timing of orthodontic treatment initiation among AA, C and H subjects (between the ages of 9 to 15 years); and orthodontic treatment should be tailored to the specific needs and maturation level of each patient.

In contrast to the present study's results, Montasser *et al.*^[15] identified significant differences in skeletal maturation among AA, C and H subjects. However, CVM stages (assessed on lateral cephalometric radiographs) instead of SMI (assessed on hand-wrist radiographs) were used to determine skeletal maturation in their study.^[15] It is hypothesized that differences in the methods used to assess skeletal age, such as SMI and CVM may lead to varying results regarding the influence of race and/or ethnicity on skeletal maturation. Further studies are needed to test this hypothesis. It has been reported that three-dimensional radiographic techniques such as cone beam computed tomography (CBCT) could provide more accurate information regarding skeletal changes compared with two-dimensional radiographic images.^[27-29] The proposed studies could also utilize CBCT to evaluate cervical growth along with SMI and dental maturation.

In the present study, dental and skeletal ages were used as indicators of individual maturation, since both of these variables have been highly correlated with growth.^[10] In addition, estimation of skeletal and dental age in this study was based on widely used and clinically relevant methods.^[4,11,19,20] Dental and skeletal ages were compared among AA, C and H subjects in the 9- to 15-year-old chronological age-groups. The rationale of including these groups is that they represent a common age range of patients presenting for orthodontic therapy. Since differences may exist in the maturation rate among AA, C and H subjects in different chronological age-groups (subjects younger than 9 years or older than 15 years), the present results should not be extrapolated to younger or older patients for age-group comparisons of skeletal and dental maturation among AA, C and H subjects younger than 9 years and older than 15 years. Furthermore, it is noteworthy that in the present study, a limited number of subjects was included in the gender ($n = 28$) and chronological ($n = 8$) ethnic subgroups, and therefore results regarding subgroup-comparisons should be interpreted with caution. Further studies are needed in this regard.

It is pertinent to mention that this study included AA, C and H subjects; and these results should not be generalized to other racial and/or ethnic groups. It is speculated that significant differences may exist in the rate of maturation among other racial groups, such as Asians, American Indians and Native Hawaiians, and others. It has been suggested that female subjects from different ethnicities mature at the same time; whereas, AA and C male subjects mature at different times.^[14] Furthermore, it has been reported that females are dentally and skeletally more advanced than males.^[30] Findings from the present study indicate that skeletal maturation was higher in females than males in all groups (AA, C and H). However, there were no gender differences in dental maturation in the AA, C and H groups. Nonetheless, in the present study, each group (AA, C and H) consisted of an equal number of male and female subjects. Further studies are needed to assess the impact of race and/or ethnicity on the maturation rate among male and female subjects, and among additional racial and/or ethnic groups.

Conclusions

Based on the present study's results, the following conclusions can be made:

1. Dental and skeletal maturation appear to be fairly similar among AA, C and H subjects between the ages 9 to 15 years
2. Skeletal maturation is higher in females than males in all groups (AA, C and H); while, there are no gender differences in dental maturation
3. Further studies are needed to evaluate and compare the rate of maturation amongst different races, genders and age groups.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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