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Third Molar Development in the Estimation of Chronologic Age in American Blacks as Compared With Whites*

ABSTRACT: Third molar (M3) development determined from dental radiographs in American blacks (African Americans; $n = 637$) aged 14–24 years was contrasted against American whites ($n = 563$) from a previous study using the method of Demirjian et al. Differences were assessed using descriptive statistics and the parametric proportional hazards model. For each developmental stage, the probability of an individual being at least 18 years old was evaluated. As in other M3 studies, there were highly significant modal differences, but the age ranges at each stage overlapped considerably. Black–white differences were highly significant with developmental stages occurring in blacks a year or so earlier. Gender differences also varied significantly, both with increasing age and between races. The empirical likelihood that an African American male with fully developed M3's is at least 18 years old is 93% and that for African American female is 84%. Corresponding risks for whites are 90% and 93%.

KEYWORDS: forensic science, odontology, age determination, third molars, African Americans

The permanent third molar (M3) is the most variable tooth with respect to size, shape, eruption timing, and the likelihood of congenital absence (1–5). Alternatively, its development is one of the very few maturation events ongoing during the late teens and early 20s. Completion of the other teeth and almost all bony development have been achieved by the mid-teens. This makes the M3 very attractive as a means of estimating a young adult's age, particularly so because its stage of crown-root mineralization can be readily assessed noninvasively from a dental radiograph. Moreover, the method is identical whether the individual is living or deceased (6).

There are, however, race and sex differences that need to be taken into account. With most maturational events, the tempo of maturation is faster in girls. This is obvious at the onset of puberty where development of secondary sexual characteristics occurs a year or so earlier in girls than in boys (7–9). Perhaps because M3s achieve much of their formation after the onset of puberty, they tend to show a reversal in sexual dimorphism, with mineralization stages achieved earlier in boys than in girls. Sex-specific standards are then required for better precision in age estimation. Race differences are much less well known. There is related evidence from tooth eruption, which broadly occurs when the M3 roots are half formed, that whites are fairly slow to erupt M3s, with blacks being faster, and Asians perhaps being intermediate (10).

The forensic relevance of these mineralization data has for the most part dealt with the likelihood that a person of unknown age is 18 or older. In the United States and other countries at that age one legally becomes an adult, and civil and criminal consequences change significantly.

The purpose of the present study was to investigate the chronology of M3 development in the African American population, because of a lack of such information reported for this ethnic group. Also, these data were compared with a previous report of the chronology of mineralization in American whites (11).

Materials and Methods

The formative status of the M3 was assessed in each quadrant in a total of 1200 individuals. Both the left and right sides in both arches were scored when possible (2177 scorable maxillary M3 and 2249 scorable mandibular M3). Most data were collected from panoramic radiographs, though periapical views (with finer resolution) were used when available. The eight-grade scheme of Demirjian et al. (12) was used as shown in Fig. 1. to classify the stage of M3 development. A preliminary training session was held to synchronize examiner grading. In each instance, the stage judged "closest" was recorded. On questionable borderline grades, inter-examiner consultation was conducted to enhance accuracy.

The subject's ethnic classification was either American white ($n = 563$) or American black ($n = 637$) based on the recorded demographic information. Data for whites were collected from several dental practices and treatment facilities across the United States and Canada as previously reported (11). Most of the data for blacks, however, were collected from the University of Tennessee College of Dentistry, a private orthodontic office in Memphis, Tennessee and an Arkansas penal facility.

Our focus was on assessing the distributions of the formative stages during late adolescence and early adulthood, so the chronological ages of the subjects examined were between 14.0 and 24.9 years. This resulted in no individuals exhibiting grade A, B, or C, and estimates of the age at grade D (crown formation complete) may be biased because some younger ages probably were truncated.

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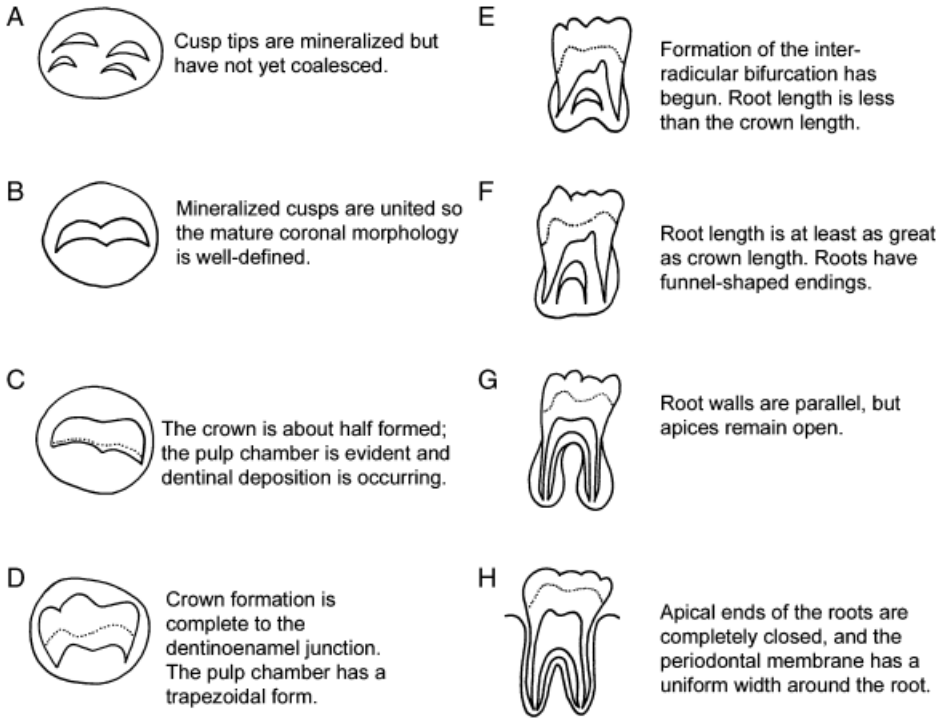

FIG. 1—*Schematic drawings and brief descriptions of the eight stages of crown and root formation used to score third molar development (modified from Demirjian et al. (12)).*

Statistics for these cross-sectional data were estimated primarily using parametric survival analysis (13,14), notably the proportional hazards model, to assess race and sex differences. Standard descriptive statistics such as the mean were calculated, as was the median, which is a better measure of the "average" person's tempo of development. Percentiles were also provided for each formative stage, specifically the 25th (the age when 25% of the sample exhibits a given stage) and the 75th percentile. The interquartile distance (i.e., the range between the 25th and 75th percentiles) is roughly equivalent to the conventional statistic of +1 standard deviation. Interquartile distances were listed because they more accurately accommodate any asymmetries in the distributions than parametric measures of dispersion.

Also determined was the likelihood that an individual in each stage of M3 development had reached 18 years of age. These were computed from equations in Fleiss (15) with 95% confidence limits.

Results

There was no side-preference in the data from both groups, but left–right asymmetry occurred in 9.0% of the maxillary pairs (93/1038) and somewhat more frequently in the mandible (13.2%; 142/1080). Almost all cases of left–right asymmetry involved a difference of just one grade as judged from the Demirjian eight-grade scheme. In just 25 cases (1.2%) there was a two-stage discrepancy (and no instance of a larger difference).

Tests for race and sex differences (Table 1) showed that the black–white differences in the tempos of M3 formation are considerable—with blacks in the early stages achieving development ahead of whites. By comparison, the male–female differences were only sporadically significant statistically. At each developmental stage, there was a wide range of ages, up to 4 years. Also, the interquartile distances (that only span 50% of the distributions) all exceeded 2 years (Tables 2 and 3).

TABLE 1—*Results of survival analyses for age and sex.*[*]

	Race			Sex			Interaction		
Grade	df	χ^2	*p*	df	χ^2	*p*	df	χ^2	*p*
Maxilla									
D	1	25.6	0.00000	1	3.6	0.0563	1	5.5	0.0189
E	1	34.5	0.0000	1	2.3	0.1294	1	4.7	0.0298
F	1	43.2	0.0000	1	1.2	0.2401	1	7.1	0.0079
G	1	17.6	0.0000	1	1.9	0.0131	1	2.3	0.1295
Mandible									
D	1	20.8	0.00000	1	4.7	0.0308	1	1.0	0.3182
E	1	42.5	0.0000	1	4.1	0.0419	1	0.1	0.7617
F	1	26.0	0.0000	1	0.0	0.9991	1	0.6	0.4439
G	1	6.9	0.0084	1	0.3	0.5907	1	14.2	0.0002

[*]Statistics are based on the proportional hazards model calculated using JMP 5.0 software package (SAS Institute, Cary, NC). Most of the race-by-sex interaction terms are significant because the rates of third molar (M3) formation are appreciably dimorphic in the American black but not the American white sample. Tests for sexual dimorphism within each ethnic group are provided in Tables 2 and 3.

TABLE 2—*Descriptive statistics for mineralization of the maxillary third molar, by race and sex.**

Group	*n*	Median	25th percentile	75th percentile	Interquartile Distance	Sex Dimorphism†	
						χ^2	*p*-Value
Grade D							
Blacks							
M	48	14.44	14.21	15.03	0.41	6.4	0.0114
F	67	14.69	14.37	15.93	0.78		
Whites							
M	55	15.71	14.64	16.81	1.09	0.2	0.8236
F	82	15.83	14.49	17.03	1.27		
Grade E							
Blacks							
M	71	15.70	15.08	16.94	0.93	9.1	0.0025
F	67	15.32	14.57	15.72	0.58		
Whites							
M	36	16.31	15.15	17.26	1.06	0.2	0.6449
F	100	16.82	15.39	18.49	1.55		
Grade F							
Blacks							
M	69	16.61	15.44	17.48	1.02	6.1	0.0139
F	80	16.15	15.19	16.79	0.80		
Whites							
M	86	17.34	15.74	18.48	1.37	0.8	0.3773
F	85	18.04	16.70	19.46	1.38		
Grade G							
Blacks							
M	119	17.85	16.62	19.20	1.29	0.1	0.7117
F	60	16.87	15.68	18.02	1.17		
Whites							
M	80	18.02	16.64	19.50	1.43	5.2	0.0228
F	125	18.73	17.08	20.53	1.73		

*Interquartile distance is the span between the 25th and 75th percentiles of the age distribution.

†In most cases (Table 1) there is a significant race-by-sex interaction term because of the significant sexual dimorphism in the American black sample but not in the American white sample. Tests here (1 df) are for a sex difference in the median age of attainment within each race, which clarify the race–sex relationships.

Comparative plots of median development for maxillary and mandibular M3s are shown in Fig. 2. Throughout these data the tempos of M3 formation—decidedly the most variable tooth in the mouth—varied appreciably, both between the sexes and between these two ethnic groups. One might suppose that the rates of maturation would parallel one another across time, but the actual data were not that simple; instead, attainment of the ordinal formation stages (which themselves were unequally spaced) varied both among the races and the sexes as maturity progressed. Also, it is important to note that the median ages shown in the tables and figures incorporated considerable variation among individuals.

In these data, blacks achieved developmental stages D, E, and F on average much earlier than whites, in some cases more than a year ahead. Also, the tempos of maturation were different between sexes in these two races during adolescence.

In later developmental stages, however, differences were more complex, with variations both between ethnic groups and genders. For example, in the maxilla both black and white males achieved stage G (complete root formation but apices open) about three-quarters of a year earlier than females on average. In the mandibular arch males achieved this stage significantly earlier than females in the white sample, but the reverse was true for the American blacks. These are prime examples of the tempos differing substantially in these two ethnic groups as well as between sexes in each race.

Attainment of Age 18 (Legal Adulthood)

The empirical likelihood that an American black or white individual is at least 18 years old at each stage of M3 development is shown in Table 4. African American females achieved each stage before white females. With males, on the other hand, African Americans reached stages E and F earlier than whites, but the reverse was true with stages G and H. Therefore, with fully developed M3s (stage H), the probability that an individual has attained his or her 18th birthday is 93% for African American males and 84% for African-American females. Corresponding risks for American whites are 90% and 93%.

Discussion

Unlike pre-mid-teen development, there are few estimators of a person's age other than the M3 (16) for our sample age group. The problem is the considerable variability of this single late-forming tooth (1–5). Some impression of the several-year range of ages is given by the Demirjian grades D through H box plots in Fig. 3. These box plots—which omit the upper and lower 10% of the range—span about 14–24 years of age. As shown, knowing the race and sex of an individual diminishes this span a bit, but not substantially. Attainment of a mineralization stage is generally normally distributed, so individuals are clustered near the median, but for a given individual one can only presume that he or she is an "average maturer," whereas, in point of fact, a given individual may be drawn from anywhere along the decade-or-so length of the range. In the late teens and early 20s there are almost no other age indicators to corroborate where a person's M3 stage might be along the observed range.

Statistically, the foremost finding in the present study was the comparatively large difference between American blacks and whites, with blacks maturing faster—at least during adolescence.

TABLE 3—*Descriptive statistics for mineralization of the mandibular third molar, by race and sex.*

Group	*n*	median	25th percentile	75th percentile	Interquartile Distance	Sex Dimorphism	
						χ^2	*p*-Value
Grade D							
Blacks							
M	51	14.70	14.35	15.44	1.09	0.4	0.3958
F	67	14.74	14.52	15.72	1.20		
Whites							
M	60	15.14	14.43	16.54	2.11	5.0	0.0248
F	88	15.93	14.80	17.29	2.49		
Grade E							
Blacks							
M	78	15.57	14.98	16.11	1.13	1.7	0.1893
F	82	15.32	14.54	16.21	1.67		
Whites							
M	57	16.66	15.66	17.90	2.24	1.4	0.2286
F	91	16.92	15.39	18.19	2.80		
Grade F							
Blacks							
M	80	16.63	15.92	17.54	1.62	0.2	0.6211
F	86	16.44	15.19	17.49	2.30		
Whites							
M	69	17.00	16.09	18.19	2.10	0.2	0.6219
F	108	17.77	16.43	18.92	2.49		
Grade G							
Blacks							
M	205	18.80	17.52	19.94	2.42	5.1	0.0235
F	80	16.85	15.81	18.87	3.06		
Whites							
M	117	17.91	16.88	19.55	2.67	9.2	0.0024
F	114	18.96	17.68	20.72	3.04		

This agrees with other studies (17,18), which documented comparable accelerated development as indicated by earlier M3 eruption in black Central African groups. Similarly, Harris and McKee (19) documented that in American blacks most mineralization stages of the entire permanent dentition were accelerated compared with American whites. Statistically, the black–white difference for M3 formation during adolescence is very highly significant—with most median differences exceeding 1 year (Fig. 2).

Mineralization of M3s, unlike other teeth, is faster in white males than white females. This "reversed" sort of sexual dimorphism agrees with results reported by prior researchers on whites (3,20,21), Hispanics (22), and Japanese (23). The data analyzed here for American blacks are different, in most stages showing the conventional precocity of females over males.

The importance of ancestry, presumably reflecting genotypic differences, is indicated when American black and white M3

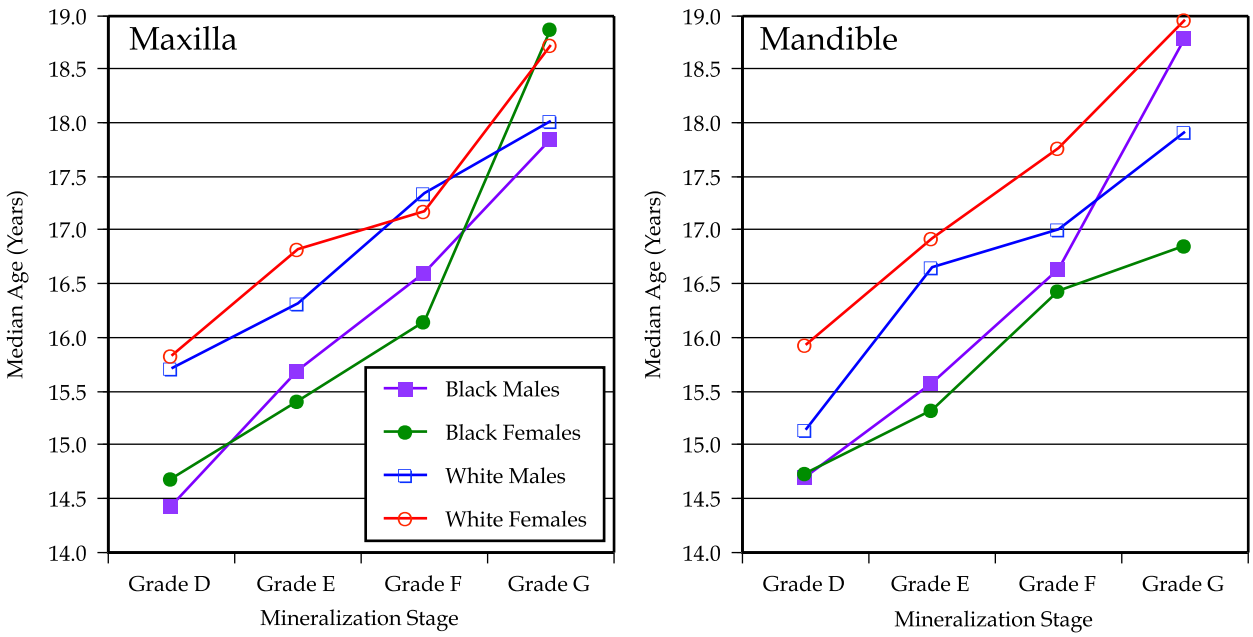

FIG. 2—*Plots of the median ages at attainment of grade D through G in the maxilla (left) and the mandible (right).*

TABLE 4—*Empirical probabilities that a person of known race (either American black or American white) and sex is 18 years of age or older.*[*]

	Males					Females			
Grade	*n*	Proportion	L_1	L_2	Grade	*n*	Proportion	L_1	L_2
American blacks									
D	0				D	63	0.048	0.012	0.116
E	76	0.132	0.068	0.185	E	82	0.024	0.004	0.079
F	80	0.150	0.083	0.200	F	86	0.186	0.113	0.231
G	205	0.634	0.564	0.644	G	80	0.325	0.227	0.366
H	343	0.927	0.893	0.928	H	125	0.840	0.761	0.847
American whites									
D	60	0.033	0.006	0.106	D	88	0.182	0.111	0.226
E	57	0.246	0.145	0.308	E	91	0.297	0.208	0.334
F	69	0.319	0.215	0.367	F	108	0.472	0.376	0.497
G	117	0.479	0.386	0.501	G	14	0.693	0.599	0.707
H	169	0.899	0.841	0.903	H	166	0.934	0.882	0.936

[*]Proportion is that part of the sample within a given grade that is 18 or older; L_1 and L_2 are the 95% confidence limits of the proportion.

mineralization data are compared for males and females. African-American male data suggest complex differences in the growth tempos. Blacks tend to achieve grades E and F ahead of whites, but the reverse trends occur for grades G and H (with considerable statistical overlap). Females show a more consistent pattern, with attainment in blacks well ahead of whites.

This study shows that M3s in American blacks mature faster than in American whites, although the opposite appears to be true in the later stages with males. Therefore, it is important to take race into account because of group differences in rates of maturation. Several recent publications (22–28) have indicated that similar differences exist among ethnicities throughout the world.

Thus, although arguably the only available biologically valid tool for age estimation in the late teen–early adult group, third molar development should be used with caution for forensic purposes because of the considerable variability among individuals—even after controlling for race and sex. Because the age range within each Demirjian stage for either American blacks or whites is so broad, an individual's age cannot be assessed with any precision using this method. Likewise, the ability to determine whether an individual is legally an adult by assessing third molar development is significantly limited.

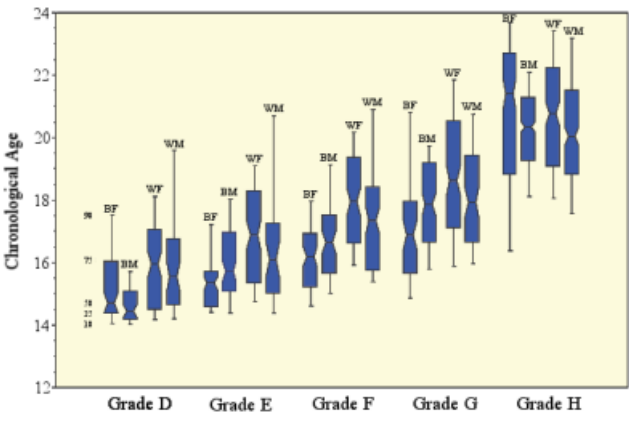

FIG. 3—*Box plots, by race and sex, for five grades of maxillary third molar formation. From bottom to top, the horizontal lines in a box plot are, respectively, the 10th, 25th, 50th (median), 75th, and 90th percentiles. Codes are black females (BF), black males (BM), white females (WF), and white males (WM). Very comparable distributions occur for the mandibular M3s.*

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