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Chronological age estimation of third molar mineralization of Han in southern China

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Abstract In order to study the chronology of age of third molar mineralization of Han in southern China, Demirjian staging method was used to determine the stage of four third molars (18, 28, 38, 48) mineralization in 3,100 Han in southern China aged 4.1–26.9 years based on radiological evidence from digital orthopantomograms. The mean age of the 3,100 patients was 15.96±4.73 years, including 1,200 male (mean age, 15.32±4.62) and 1,900 female (mean age, 16.35±4.76). Results show that there was no significant difference in mineralization between 18 and 28 and 38 and 48 of male or female. However, significant difference was observed between 28 and 38 of female at stage C; 28 was 0.25 years earlier than 38. In male, at stage G, 38 was 0.61 years earlier than 28, and 48 was 0.62 years earlier than 18. At stages D, E, F, G, and H, male 48 was 0.34, 0.66, 0.72, 1.34, and 0.76 years earlier than that of female, respectively. At stages A, D, E, F, G, and H, male 38 was 0.73, 0.26, 0.56, 0.91, 1.29, and 0.70 years earlier than that of female, respectively. At stages B, E, F, G, and H, the mineralization mean age of male 18 was 0.54, 0.50, 0.76, 0.92, and 0.58 years earlier than that of female, respectively. At stages E, F, G, and H, the mineralization mean age of male 28 was 0.51, 0.76, 0.92, and 0.49 years earlier than that of female, respectively. After reviewing the literature, the chronological mineralization age of 48, at stages D to G, of Han in southern China was 1 to 4.6 years earlier than that of Japanese and 1 to 3 years earlier than that of German. The mean age at stage H of 48 of Han in southern China was similar to Turkish, Black African, Japanese, and German, but was later than Spanish. Finally, the conclusions are: (1) in the same gender group of Han in southern China, the mineralization ages between two sides in upper or lower jaw are very similar, and (2) the chronology mean age and complete time of third molar mineralization of male were earlier than that of female.

Keywords Third molar · Dental development · Dental mineralization · Age

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Introduction

In recent years, the forensic age determination of living people has become more and more important. There are many skeletal indicators for forensic age estimation in youth, such as diaphysis–epiphysis fusion, hand–wrist examination, cervical vertebrae assessment, fusion of cranial sutures, changes in secondary sex characteristics, and so on; all of which have their advantages and disadvantages [1–6].

Teeth represent useful information for age estimation in childhood, for example, observing dentition stages results in highly accurate age assessments. However, this accuracy decreases after dental development is completed [7]. Therefore, radiographic assessment of third molar mineralization becomes a particularly important method for forensic age estimation. Many research papers have reported age estimation in youth through evaluating third molar mineralization [4–6]. However, the influence of geographic origin on the mineralization rate has been

insufficiently analyzed. Research in different ethnic populations varied in the results of age estimation [6, 8–10].

So far, after reviewing the literature, no report was seen on the research of age estimation in Chinese. Because Han is the largest population in China and worldwide, therefore, to estimate the age by evaluating the radiographic features of third molar mineralization in young Han would be very meaningful for forensic age estimation. In the present study, the chronological age based on third molar development of Han in southern China is studied, and a comparison is performed with results of previous studies on other ethnic populations.

Materials and methods

Orthopantomograms were performed with a total of 3,153 Han in southern China from the ages of 4.1 to 26.9 years. In 53 cases, all four third molars were lost, so these cases were excluded. The overall statistical analysis is, therefore, based on 3,100 people. The mean age was 15.96±4.73 years, including 1,200 male (mean age, 15.32±4.62) and 1,900 female (mean age, 16.35±4.76). All orthopantomograms were taken by digital orthopantomogram X-ray machine (Sirona, orthophos, Germany) in Radiology Department of the Affiliated Hospitals of Stomatology of Sun Yet-sen University. The radiological examinations were performed from January 2008 to June 2009. The patients' ethnic name, gender, and birth date were recorded for every radiograph. Selection criteria include the following: (1) southern Chinese and Han, (2) well nourished and free of any known serious illness, and (3) normal growth and development and dental conditions. Exclusion criteria included the following: (1) image deformity affecting third molars and (2) orthopantomogram showing obvious dental pathology, such as dentigerous cyst of third molar.

All assessments of the orthopantomograms were performed on EIZO Flexscan S2100 medical liquid crystal display (LCD). The luminance of the room was 50 lux. The brightness of LCD was 300 cd/m^2. Evaluation and classification covered the development phase of four third molars, 18, 28, 38, and 48. Tooth mineralization was evaluated according to the method described by Demirjian et al. [11]. The development and mineralization of third molars were classified into eight stages (A–H): first four stages (A–D) show crown calcification from the appearance of cusp to completion of crown, and second four stages (E–H) show root formations from radicular bifurcation beginning to apical closing.

All data were analyzed using the SPSS software package (SPSS for Windows 2000, version10.0). Descriptive statistics were obtained by calculating the means, standard deviations, and range of the chronologic ages for the eight stages of dental development. Statistical analyses were performed using the Student's t test between male and female.

The mineralization stages were evaluated by two radiologists, 1,600 cases by one radiologist and 1,500 cases by the other radiologist. We used the following method to test the consistency of assessments of dental development stage between the two radiologists and the reproducibility of the same radiologist. First, 300 orthopantomograms were randomly selected. Then, all 300 orthopantomograms were evaluated by both radiologists. Four weeks after the first evaluation, these orthopantomograms were re-evaluated by both radiologists again. Finally, Wilcoxon matched-pairs signed-rank tests were performed to analyze the evaluation results.

We then primary compared the difference of the chronological age of third molar mineralization between Han in southern China and other ethnic populations by reviewing the data from previous studies. The chronological mineralization age of Japanese, Black African, German, Turkish, and Spanish [6, 8–10, 12] were compared with that of Han in southern China. The mean chronological age of 48 was selected for the comparison.

Results

Repeated scorings of 300 orthopantomograms indicated no significant intraobserver or interobserver differences ($P>0.05$). Intraobserver consistency was rated at 97.5%, whereas interobserver agreement was 96.3%.

The mean mineralization ages and standard deviations for the Demirjian stages of third molars are described in Tables 1, 2, 3, and 4.

Differences of chronological age between 18 and 28 and 38 and 48 were tested. No significant difference was found between 18 and 28 and 38 and 48 of male or female.

There was significant difference between 28 and 38 of female at stage C; 28 was 0.25 years earlier than 38, $P=0.02$. No significant difference was found between 18 and 48 of female. In male, at stage G, 38 was 0.61 years earlier than 28, and 48 was 0.62 years earlier than 18.

The difference of molar mineralization age between genders was also compared. There was no difference between male and female 48 at stages A, B, and C, but at stages D, E, F, G, and H, male 48 was 0.34, 0.66, 0.72, 1.34, and 0.70 years earlier than that of female 48, respectively. No significant difference was found between male and female 38 at stages B and C, but at stages A, D, E, F, G, and H, male 38 was 0.73, 0.26, 0.56, 0.91, 1.29, and 0.70 years earlier than that of female, respectively. No significant difference was found between male 18 and female 18 at stages A, C, and D, but significant difference

Table 1 Statistic data of chronological mineralization age of 48

Stage	Male					Female					*P* value
	Number	Mean	SD	Min	Max	Number	Mean	SD	Min	Max	
A	54	9.86	1.66	7.50	14.00	46	10.25	1.89	7.50	15.50	0.38
B	105	10.92	1.50	7.30	15.70	104	11.05	1.25	7.70	14.00	0.17
C	263	12.57	1.33	8.60	17.20	376	12.61	1.48	5.90	22.20	0.70
D	217	13.52	1.49	8.60	18.60	443	13.86	1.72	7.50	19.90	0.01*
E	113	15.13	1.59	12.40	20.20	206	15.79	1.80	11.90	21.30	0.001*
F	71	17.13	1.76	14.20	21.60	122	17.85	2.06	14.00	22.50	0.01*
G	111	19.28	1.84	15.50	24.80	232	20.62	2.21	15.20	26.50	0.00*
H	218	22.68	2.28	18.10	26.90	356	23.38	2.02	17.60	26.90	0.00*

*$P<0.05$

was found at stages B, E, F, G, and H, 0.54, 0.50, 0.76, 0.92, and 0.58 years earlier in male than in female, respectively. No significant difference was found between male 28 and female 28 at stages A, B, C, and D, but the significant difference was found at stages E, F, G, and H, 0.51, 0.76, 0.92, and 0.49 years earlier in male than in female, respectively.

The chronological mineralization age of 48, at stages D to G, of Han in southern China was 1 to 4.6 years earlier than that of Japanese and 1 to 3 years earlier than that of German. The mean age at stage H of 48 of Han in southern China was similar to Turkish, Black African, Japanese, and German, but was later than Spanish.

Discussion

According to the recommendations of the Study Group on Forensic Age Diagnostics for age estimations in living individuals [13], there are several examinations should be performed together in order to increase the diagnostic accuracy and to improve the identification of age-relevant developmental disorders, such as a physical examination, an X-ray examination of the left hand, dental examination including the determination of the dental status, an X-ray of the dentition, and so on. The skeletal age determination and dental age estimation are very important methods for age estimation. The clinically prevalent skeletal age determination method for forensic age estimation in living individuals is TW2 and TW3 methods which presented by Tanner and Whitehouse [14].

Dental age estimation is also an important method on Forensic Age Diagnosis [13]. There are some methods for dental age estimation through evaluating the chronological age of tooth mineralization. These methods were presented by Gleiser and Hunt [15], Moorrees et al. [16], Kullman et al. [17], Kvaal et al. [18], and Paewinsky et al. [19]. However, results vary among the studies using these methods. Some results were too subjectively evaluated to be compared directly [9]. Landa et al. [20] tested the reproducibility and to evaluate the application of regression formulae reported by Kvaal et al. [18] and Paewinsky et al. [19] on the values from the sample studied. They found that the method reported by Kvaal et al. cannot be applied to

Table 2 Statistic data of chronological mineralization age of the 38

Stage	Male					Female					*P* value
	Number	Mean	SD	Min	Max	Number	Mean	SD	Min	Max	
A	63	9.82	1.47	7.50	13.50	51	10.55	1.82	7.50	15.80	0.02*
B	105	11.10	1.67	7.30	16.20	113	11.02	1.37	7.70	14.00	0.80
C	260	12.55	1.31	8.60	17.20	385	12.67	1.50	5.90	22.20	0.27
D	212	13.47	1.48	8.60	18.60	439	13.73	1.73	7.50	19.90	0.001*
E	117	15.31	1.73	12.40	21.20	197	15.87	1.95	11.90	24.70	0.01*
F	68	17.06	1.62	14.20	21.60	124	17.97	2.10	14.00	22.60	0.001*
G	110	19.32	1.79	15.50	24.80	221	20.61	2.25	15.20	26.50	0.00*
H	213	22.72	2.27	18.10	26.90	356	23.42	2.02	17.60	26.90	0.00*

*$P<0.05$

Table 3 Statistic data of chronological mineralization age of 18

Stage	Male					Female					*P* value
	Number	Mean	SD	Min	Max	Number	Mean	SD	Min	Max	
A	25	10.49	1.50	8.40	13.2	13	10.12	1.84	7.50	13.0	0.49
B	63	10.60	1.50	7.30	14.20	61	11.14	1.41	7.70	14.30	0.04*
C	226	12.44	1.43	8.60	20.80	333	12.41	1.53	7.50	22.20	0.79
D	286	13.64	1.60	8.60	19.10	506	13.80	1.63	9.70	19.70	0.17
E	92	15.55	1.79	12.40	21.20	181	16.05	1.84	12.10	21.80	0.03*
F	71	17.45	1.66	14.50	21.50	99	18.21	1.98	14.00	24.10	0.01*
G	103	19.90	1.98	15.80	26.00	218	20.82	2.35	15.20	26.90	0.00*
H	192	22.75	2.27	18.10	26.90	342	23.33	2.00	17.70	26.80	0.01*

*$P<0.05$

direct digital orthopantomograms. The values of age estimation obtained using regression formulae analyzed on digital images were so distant from the real ages that this method must be discouraged as being a reliable one to estimate age on a direct digital orthopantomograms sample.

Demirjian et al. [11] presented a different classification method. This method differentiates eight stages of crown and root development (stages A–H). Stages A, B, C, and D represent crown development, while stages E, F, G, and H represent root development. The stages proposed by Demirjian are defined only by changes in shape or proportions, and no metric estimations are defined. Therefore, this classification is simpler and more objective. Olze et al. [21] assessed the validity of the common classification systems defined by Gleiser and Hunt, Demirjian et al., Gustafson and Koch, Harris and Nortje, and Kullman et al. They found that the most accurate results were obtained with the staging system of Demirjian et al. Therefore, we selected this method for present study.

So far, there is no consistent conclusion about how the ethnicity influences the mineralization of the third molar. Different results were obtained by different authors to study the chronological age of different ethnic groups using the classification method proposed by Demirjian. Olze et al. [8] used this method to study third molar mineralization of 595 Black African. The results showed that male low third molar reached stage F 0.8 years earlier than that of female. No difference was found between left and right sides of male upper and lower third molars. Significant gender difference was found for the ages at which left low third molar reached the stage G. Female left low third molar reached stage G 1.5 years earlier than male.

Sisman et al. [6] studied third molar development of 900 Turkish people. They found that statistically significant difference in third molar development between male and female were revealed regarding the calcification stages D and G. Third molar genesis was attained earlier in male than in female. Statistical analysis showed a strong correlation between age and third molar development for male and for female.

Olze et al. [9] compared the mineralization age of Japanese and German. The results shown that significant difference between Japanese and German was observed at stages D, E, and F as defined by Demirjian. Japanese men

Table 4 Statistic data of chronological mineralization age of 28

Stage	Male					Female					*P* value
	Number	Mean	SD	Min	Max	Number	Mean	SD	Min	Max	
A	30	10.03	1.41	7.70	13.00	11	10.21	1.65	7.50	12.30	0.75
B	63	10.98	1.55	8.90	15.00	69	11.20	1.42	7.70	14.20	0.40
C	233	12.51	1.33	8.60	17.20	335	12.42	1.48	8.40	22.20	0.44
D	275	13.58	1.62	8.60	22.00	504	13.82	1.65	9.70	19.30	0.052
E	94	15.64	1.80	12.40	21.20	183	16.15	1.95	12.10	22.60	0.03*
F	70	17.47	1.66	14.50	21.50	96	18.23	1.91	14.00	22.30	0.01*
G	104	19.93	2.01	15.80	26.00	224	20.85	2.37	15.20	26.90	0.00*
H	192	22.81	2.26	18.10	26.90	339	23.30	1.98	17.70	26.80	0.02*

*$P<0.05$

and women reached the D, E, and F stages approximately 2–3 years later than German men and women.

Olze et al. [10] also evaluated the chronological age of third molar mineralization of 1,615 Japanese. No statistically significant difference in the chronology of third molar mineralization between maxilla and mandible and between left and right sides was observed. A comparison between genders did not render significant difference, either.

Prieto et al. [12] studied third molar mineralization of 1,054 aged 14 to 21 Spanish. They found that the development of male third molar was earlier than that of female at stages E, F, and G. No difference was found between left and right sides. Third molar maturity takes place earlier in Spanish than in French-Canadian, Scandinavian, American, German, Japanese, and South African populations, but it is more similar to US Hispanics in root development.

In this study, regardless male or female, the chronological age of third molar mineralization for Han in southern China was symmetrical of left and right sides. No difference was found between the two sides in the same gender group. This result was similar to other researchers' results obtained from studies in other ethnic populations [12].

However, the chronological mineralization age of Han was 1 to 4.6 years earlier than that of Japanese when third molar reached stage D to G and 1 to 3 years earlier than that of German. According to the report of Olze et al. [9], Japanese was later than German when third molar reached stage D to G. Because both Han in southern China and Japanese belong to Asian, it is puzzling why there is big difference in the third molar mineralization chronological age. More studies may be needed to clarify this. In summary, the chronological age of third molar mineralization should be further studied to determine and decipher the real difference among different geographic groups, to have a more accurate estimation of the chronological ages.

Finally, we draw the conclusions: (1) in the same gender group of Han in southern China, the mineralization ages between two sides in upper or lower jaw are very similar, and (2) the chronology of mean age and complete time of third molar mineralization of male were earlier than that of female.

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