ORIGINAL ARTICLE

Radiographic correlation of dental and skeletal age: Third molar, an age indicator

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Abstract

Background: Age estimation plays a great role in forensic investigations, orthodontic and surgical treatment planning, and tooth transplantation. Teeth offer an excellent material for age determination by stages of development below the age of 25 years and by secondary changes after the age of 25 years. Third molar is often not included for this purpose due to its notorious developmental patterns. The aim of this study was to evaluate the development of third molar anlage in relation to skeletal maturities and the chronological age. **Materials and Methods:** One hundred and fifty-six young individuals, 78 males and 78 females, were selected. The stages of development of all the third molars in every individual were determined from panoramic radiographs. The skeletal development was assessed using hand wrist radiographs. Data were analyzed statistically for mean value, standard deviation and the relationship between the recorded characteristics. **Results:** A strong correlation was found between third molar development and skeletal maturity (in males: r=0.88, *P*<0.001; in females: r=0.77 for maxillary third molar and 0.89 for mandibular third molar, *P*<0.001). **Conclusion:** Hence, it is concluded that a strong correlation exists between chronological age, developmental stages of third molars and maturation of epiphyses of hand. Any of the three parameters could be used for the assessment of other maturities.

Key words: Age estimation, dental, developmental stages, skeletal, third molar

Introduction

Age estimation plays a great role in forensic investigations, orthodontic and surgical treatment planning, and tooth transplantation.[1] In forensic applications, chronological as well as maturational stages of an individual are often determined by assessing the stages of tooth development. Teeth offer an excellent material for age determination by stages of development below the age of 25 years and by secondary changes after the age of 25 years.[2] Third molar is often not included for this purpose due to its notorious developmental patterns.

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The aim of this study was to evaluate the development of third molar anlage in relation to skeletal maturities and the chronological age.

Materials and Methods

The study population consisted of 156 (78 males and 78 females) subjects in the age group of 97–252 months; they were divided into 13 groups, with each group spreading over a period of 12 months. Each group consisted of 12 subjects. They were selected at random from the outpatient department, Department of Oral Medicine and Radiology, Bapuji Dental College and Research Centre, Davangere. Informed consent was obtained from each participant.

Subjects with known skeletal, musculoskeletal and endocrinal diseases were not included in the study.

The stages of development of all the third molars in every individual were determined from panoramic radiographs. The development stage and third molars were categorized into one of the following stages (as per Nolla's method) [Figure 1]:[3]

1. C_0: crypt present
2. C_i: initial cusp calcification
3. $C_{1/3}$: one-third of the crown complete
4. $C_{2/3}$: two-thirds of the crown complete
5. C_c: crown complete
6. $R_{1/3}$: one-third of the root complete
7. $R_{2/3}$: two-thirds of the root complete
8. R_c: root formation complete but apex not closed

A hand wrist radiograph was also made for all individuals and the skeletal development was classified as follows (as per Engstrom *et al*., in 1983)[3] [Figure 2]:

1. PP_2: proximal phalanx of second finger, the epiphysis as wide as the diaphysis
2. MP_3 cap: middle phalanx of third finger, the epiphysis caps its diaphysis
3. DP_3u: distal phalanx of third finger, complete epiphyseal union
4. Ru: distal epiphysis of radius, complete epiphyseal union

Data were analyzed statistically for mean value and standard deviation, and the relationship between the recorded characteristics was evaluated by correlation (Karl–Pearson Correlation Constant) and linear regression analysis. Differences between males and females were tested with Student's "*t*" test and "*z*" test.

Results

The mean ages for the different stages of third molar development in males are 174.08 months and in females are 176.8 months [Tables 1 and 2]. No statistically significant sex differences were found, although development appeared to be slightly earlier in girls than in boys [Figure 3].

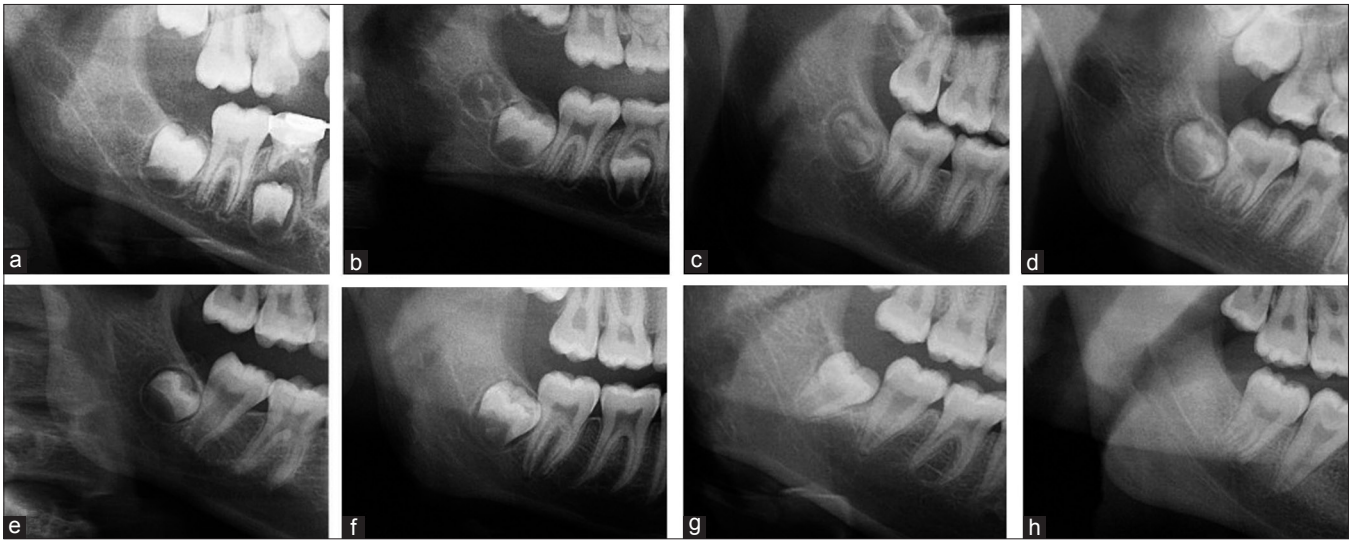

Figure 1: Developmental stages of third molar

Figure 2: Radiograph of hand showing ossification centers used for staging of skeletal development

Figure 3: Radiographs of an 11-year-old boy demonstrating skeletal stage PP2 on hand wrist and third molar in dental stage C_1

Table 1: Mean age in months for different stages of maxillary third molar development in females (166.8) and males (174.08)

Stages	Female			Male		
	n	Mean age	SD	*n*	Mean age	SD
1	1	103	-	4	111	5.9
2	6	129	15.2	15	125	12.9
3	13	130	16.0	19	144	16.2
4	7	145	26.8	5	147	11.4
5	23	166	19.5	20	177	15.0
6	16	194	26.9	16	192	17.6
7	4	208	22.0	14	211	11.5
8	7	221	19.7	13	237	10.6
Total	77	166.8	37.3	106	174.08	40.4

Table 2: Mean ages in months for different stages of mandibular third molar development in females (174.02 months) and males (176.8 months)

Stages	Female			Male		
	n	Mean age	SD	*n*	Mean age	SD
1	10	104	8.3	10	126	27.2
2	11	134	30.7	27	128	13.9
3	18	143	15.2	10	146	7.9
4	13	155	14.9	7	165	18.3
5	20	166	24.2	15	182	20.4
6	17	199	18.3	25	189	18..6
7	24	222	19.0	23	217	15.0
8	15	223	15.8	15	240	8.7
Total	128	174.02	43.34	132	176.8	42.17

On the whole, a strong correlation was found between chronological age and third molar development stages in both the sexes [in males: *r* (correlation coefficient)=0.93 for maxilla and 0.91 for mandible, *P*<0.001; in females: *r*=0.82 for maxilla and 0.89 for mandible, *P*<0.001] [Figures 4 and 5].

A strong correlation was found between chronological age and skeletal maturity (in males: *r*=0.88, *P*<0.001; in females: *r*=0.87, *P*<0.001) [Figure 6].

Also, a strong correlation was found between third molar development and skeletal maturity (in males: *r*=0.88, *P*<0.001; in females: *r*=0.77 for maxillary third molar and 0.89 for mandibular third molar, *P*<0.001) [Figures 7 and 8].

The distribution of the different dental stages at various skeletal stages is as follows [Figure 9a-d]:

At PP_2

Maxillary and mandibular third molar showed signs of completed one-third crown mineralization, equally distributed in dental stage 2 and 3.

At MP_3 cap

Both maxillary and mandibular third molar crown formation was completed (in majority of subjects) and root development had begun in some individuals.

At DP_3u

Both maxillary and mandibular third molars were seen to complete one-third root formation in majority of cases.

At stage Ru

Majority of maxillary and mandibular third molars completed root formation, but had attained two-thirds of the root formation in others.

Number of missing third molars was 21.2% out of which maxillary third molars formed 64.4% and mandibular third molars formed 35.6%. The difference was statistically significant (*P*<0.001).

Discussion

Teeth represent one of the most reliable indicators of chronological age from birth up to 14 years. Beyond 14 years, age determination based on tooth development depends primarily on the root development of second and third molars.[3,4] Tooth development shows less variability in relation to chronological age.[5] This study was conducted with an aim to correlate the chronological age, dental maturity and skeletal maturity.

Mean age of the present study group was 174.08 months for males and 176.8 months for females, in the age group of 97–252 months. The mean age of the study group was not found to be consistent with that reported in previous

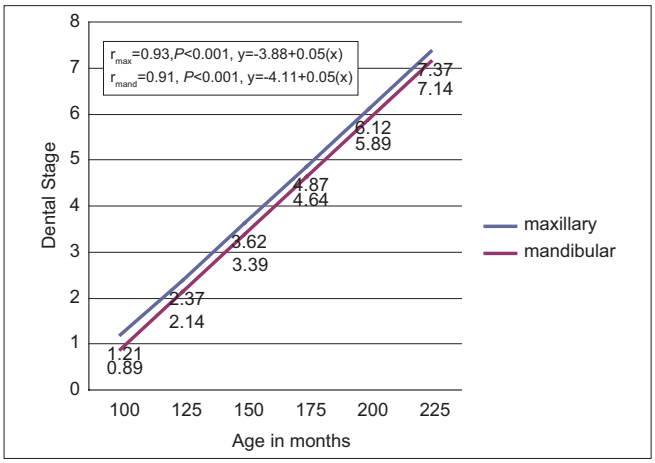

Figure 4: Diagram showing the relationship between chronological age in months (horizontal axis) and dental stage (vertical axis) in males (both maxillary and mandibular third molars). Estimated regression equation, correlation coefficient (*r*) and significance levels (*P*) are also shown

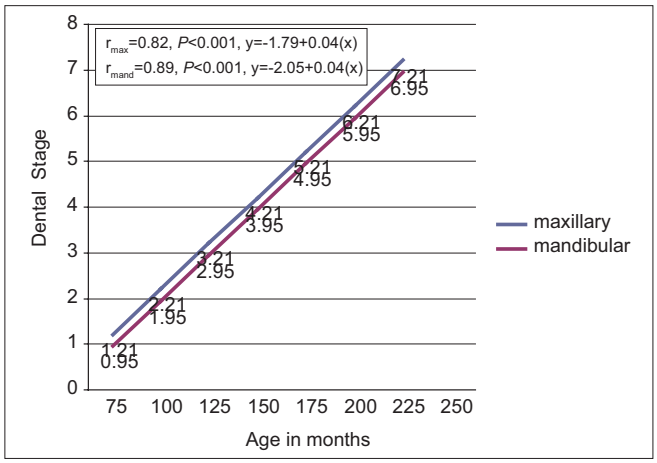

Figure 5: Diagram showing the relationship between chronological age in months (horizontal axis) and dental stage (vertical axis) in females (both maxillary and mandibular third molars). Estimated regression equation, correlation coefficient (*r*) and significance levels (*P*) are also shown

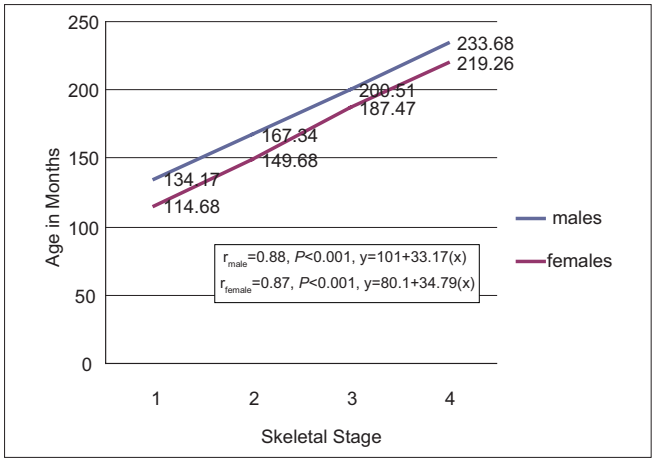

Figure 6: Diagram showing the relationship between skeletal stage (horizontal axis) and chronologic age (vertical axis) in males and females combined. Estimated regression equation, correlation coefficient (*r*) and significance levels (*P*) are also shown

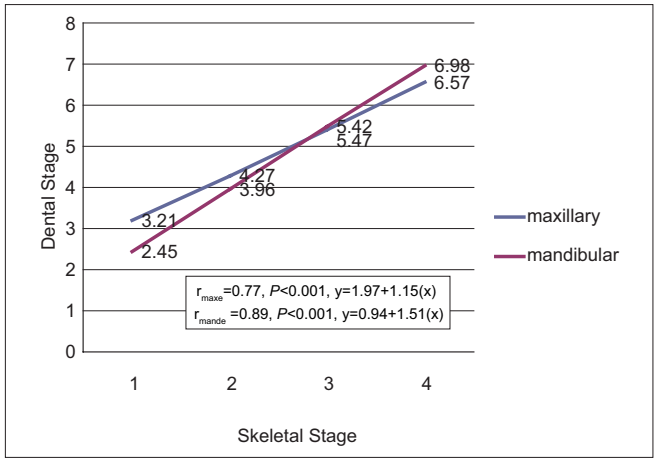

Figure 7: Diagram showing the relationship between skeletal stage (horizontal axis) and dental stage (vertical axis) in females. The estimated regression equation, correlation coefficient (*r*) and significance levels (*P*) are also shown

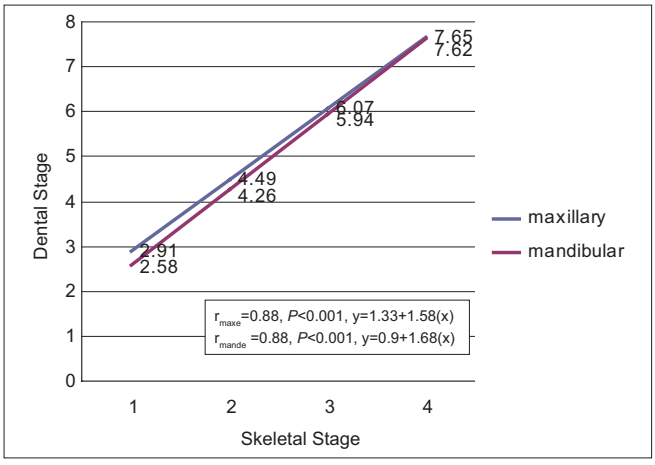

Figure 8: Diagram showing the relationship between skeletal stage (horizontal axis) and dental stage (vertical axis) in males. The estimated regression equation, correlation coefficient (*r*) and significance levels (*P*) are also shown

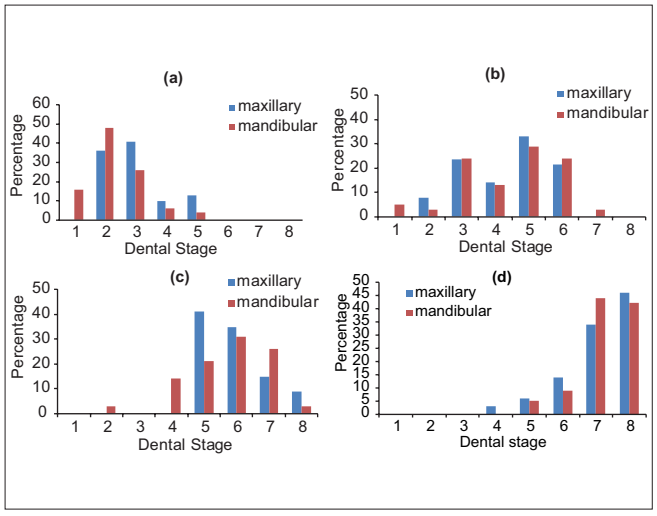

Figure 9 (a-d): Distribution of dental stages for males and females combined at each skeletal stage

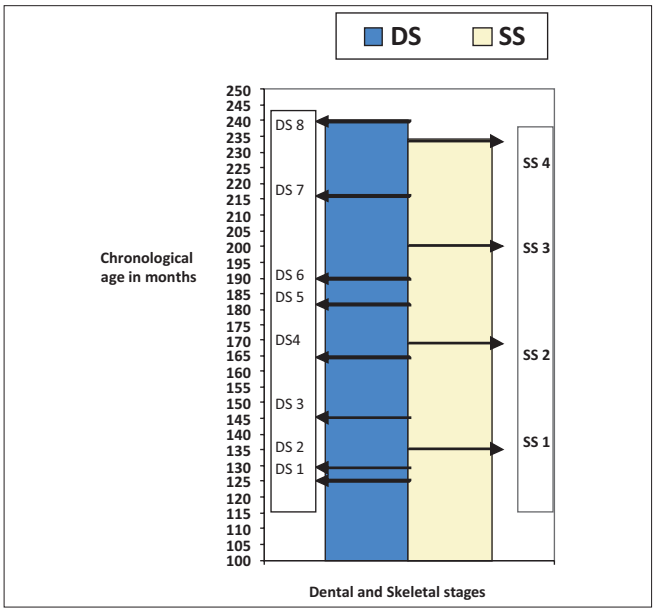

Figure 10: Diagram showing the relationship between the chronological, dental and skeletal ages

studies, that is, 182 months and 185 months reported by Engstrom *et al*.,[3] 132.12 months reported by Pareikh and Parulkar,[4] and 144 months reported by Demisch and Wartmann.[6] This can be explained on the basis of dissimilar age groups of the study subjects.

Mean dental stage for males was 4.82 months for maxillary and 4.73 months for mandibular third molars, and for females it was 4.88 months for maxillary and 4.91 months for mandibular third molars. The figures are not consistent with that of 3.48 for males and 3.58 for females reported by Engstorm *et al*.[3] The disagreement in the values could be attributed to the different methodologies employed in staging the development of third molar as the tooth development was measured over eight stages in the present study instead of five as per Engstorm *et al*. However, the correlation coefficient for comparing dental and chronological age was statistically significant with a $P<0.001$ similar to that reported by Engstrom *et al*.,[3] Pareikh and Parulkar,[4] and Demisch and Wartmann.[6]

Skeletal maturity has shown to be a better indicator of age in previous studies. In the present study, the subjects were found to have normal skeletal development as shown from the strong correlation between chronological and skeletal age, which is consistent with the reports of Engstrom *et al*.[3] and Demisch and Wartmann (1956).[6]

A strong correlation between dental and skeletal maturities was demonstrated with $r=0.88$ for both maxillary and mandibular third molars in males, 0.77 for maxillary and 0.89 for mandibular third molars in females, with $P<0.001$. The figures are not consistent with the values of Engstrom *et al*. (0.72),[3] Pareikh and Parulkar (0.80),[4] Demisch and Wartmann (0.86 for males, 0.75 for females),[6] Sierra (0.62–0.82),[7] and Lamans *et al*. (0.93 for males and 0.83 for females).[8] This can be explained based on the fact that in the present study the results were discussed for males and females, maxillary third molars and mandibular third molars separately, which was not so in any of the above-mentioned studies. However, the *r* values of the present study are highly significant with $P<0.001$.

At skeletal stage PP_2, about one-third of crown mineralization was complete, at MP_3 cap stage most of the third molars had completed the crown mineralization, at DP_3u most of the third molars had completed one-third root formation, and at Ru stage majority had completed the root formation.

Incidence of missing third molars in the present study was 21.2%, which was higher in maxillary third molar (64.4%) than in the mandibular third molars (35.6%). The difference was statistically significant with $P<0.001$. No statistically significant difference was seen in third molar development in males and females.

Hence, it is concluded that a strong correlation exists between chronological age, developmental stages of third molars and maturation of epiphyses of hand [Figure 10], which is statistically highly significant with $P<0.001$. The chronological age can be determined from dental maturity in the range of 1–5 years and skeletal maturity in the range of 2–4 years. The study is limited in cases of all the third molars missing. Since the number of missing maxillary third molars was more, it can be inferred that mandibular third molars could be more reliable for age estimation. We suggest that further studies could be attempted with a large sample size and using teeth other than third molars.

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