Original Article

Age estimation using development of third molars in South Indian population: A radiological study

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Abstract

Aim: To assess the estimation of chronological age based on the stages of third molar development following the eight stages (A–H) method of Demirjian et al. in Chennai population of South India. **Materials and Methods:** A sample consisting of 848 individuals (471 males and 377 females) aged between 14 and 30 years was randomly selected for the clinical evaluation and 323 orthopantomograms with clinically missing third molars were taken for radiological evaluation using Demirjian's method from a Chennai population of known chronological age and sex. Statistical analysis was performed using Pearson's Chi-square test and mean values were compared between the study groups using t-test or analysis of variance (ANOVA) followed by Tukey's highly significant difference (HSD). In the present study, $P < 0.05$ was considered as the level of significance. **Results:** The results showed that the mean age of having clinically completely erupted maxillary third molars was 22.41 years in male subjects and 23.81 years in female subjects and that of mandibular third molars was 21.49 years in male subjects and 23.34 years in female subjects. Mandibular third molars were clinically missing more often in females than in males. Eruption of mandibular third molars was generally ahead of the emergence of maxillary third molars into the oral cavity. Third molar development between male and female subjects showed statistically significant differences at calcification stage F and stage G in maxillary third molars and stage F in mandibular third molars ($P < 0.05$). **Conclusion:** There are differences indicating that maxillary and mandibular third molar eruption reached Demirjian's formation stages earlier in males than in females. It is suggested that in future studies, to increase the accuracy of age determination, indications of sexual maturity and ossification should also be evaluated in addition to third molar mineralization.

Key words: *Age estimation, Demirjian methods, dental age estimation, forensic odontology, radiographic age, third molar*

INTRODUCTION

Information on the timing and sequence of tooth eruption is of interest in studying the growth and development of the jaws and teeth. There are many methods to determine the chronological age of children and adults. These methods can be broadly divided into two main groups: (1) Studies based on bone maturity and (2) studies based on tooth development and eruption. The methods using skeletal maturity are mainly based on radiographs of specific structures, such as epiphysis–diaphysis fusion of long bones, medial extremity of the clavicle, epiphyseal head of the first rib, epiphyseal union of the anterior iliac crest, and fusion of the sphenoid bone with the basilar part of the occipital bone.[1] The most frequently used methods are based on dental development visualized by orthopantomogram or cephalometric

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radiograph.[2] The presence or absence of third molars, the age at which they develop, the time of eruption, and the position and direction of eruption are significant to all branches of dentistry and, in particular, forensic dentistry.

Several authors have stated that the formation of the third molars is the only quantitative biological variable available for estimating the age of an individual in the early twenties.[1]

There is great variation in the timing of development, calcification, and eruption of third molars or wisdom teeth. Development of wisdom teeth may begin as early as 5 years or as late as 6 years, with the peak formation period at 8 or 9 years. Calcification can start at age 7 years in some children and as late as 16 years in others. Enamel formation is normally completed between 12 and 18 years and root formation is normally completed between 18 and 25 years.[3]

Third molar emergence spans between 12 and 22 years. Radiographic analysis of third molar development expands age estimation to 9–23 years of age, as crown and root development can be studied independent of eruption.[4]

The eruption of third molars has been reported to vary with the ethnicity of individuals. Studies performed on Western population have reported the eruption of third molars to range between 17 and 21 years of age.[5]

On the other hand, a study performed among rural Nigerians has reported the average age of initial eruption of third molars to be 15 years among male subjects and 13 years among female subjects. We attempted to evaluate the eruption status of third molars in Chennai population, Tamil Nadu, South India by clinical and radiological examination in this study. The aims and objectives of this study were to:

- Assess third molar eruption status in a sample of Chennai population
- Assess the mean chronological age for each developmental stage using Demirjian method in third molars; and
- Compare the values obtained for the eruption status of third molars in our study with the results of other studies.

MATERIALS AND METHODS

In this study, a sample consisting of 848 individuals (471 males and 377 females) between 14 and 30 years of age was randomly selected for clinical evaluation and 323 orthopantomograms with clinically missing third molars were taken for radiological evaluation using Demirjian's method from a Chennai population of known chronological age and sex. The methods of Demirjian, Goldstein, and Tanner are the widely used methods for age determination based on eight calcification stages which span from the first sign of tooth calcification to apex closure for permanent mandibular teeth. In Demirjian's method, a score is allocated for each stage and the sum of the scores provides an estimation of the subject's dental maturity. The overall maturity score may then be converted into dental age by using available tables and percentiles curves.

Collection of data

Data were collected using the following.

Inclusion criteria were:

- Subjects in the age group of 14–30 years
- Only South Indian people were included in the study.

Exclusion criteria were:

- Previous history of surgical removal of third, second, or first molar
- Previous history of surgery in the posterior jaws
- Previous history of any pathology of development anomalies like cleft palate and syndromes
- Previous history of orthodontic treatment
- Orthopantomograms showing obvious dental pathology
- Congenitally missing third molars were not included.

The subjects were examined under adequate illumination using sterilized mouth mirrors and probes for the eruption of third molar.

Clinical evaluation of the eruption status of third molars

- Third molars which had erupted to the level of occlusal plane and were completely visible [Figure 1]
- Partially erupted third molars and partially visible clinically
- Clinically invisible third molars that had not yet perforated the oral mucosa [Figure 2].

Radiological evaluation of the eruption status of third molars

Only clinically missing third molars were examined with orthopantomograph radiographs. The dental digital panoramic radiographs (taken using Planmeca machine) were examined on a computer monitor to

permit an accurate reading for rating the degree of calcification of each tooth.

Tooth calcification was rated according to the method described by Demirjian *et al*. in which one of the eight stages of calcification, A–H, was assigned to the third molar tooth. The first four stages (A–D) show crown formation from the beginning of cusp calcification to the completed crown and the other four stages (E–H) show root formations from initial radicular bifurcation to apical closing.

Shown in Figure 3. [Figure 3 demonstrates Demirjian formation stage D].

Statistical analysis

Statistical analysis was done using Statistical Package for Social Sciences (SPSS) software version 17. Comparison of proportions of various characteristics was done using Pearson's Chi-square test or Chi-square test with Yates's continuity correction or Fisher's exact test. Mean values were compared between the study groups using either Student's independent *t*-test or one-way analysis of variance (ANOVA) followed by Tukey's highly significant difference (HSD) procedure to identify the significant groups. In the present study, $P < 0.05$ was considered as the level of significance.

RESULTS

The study sample consisted of 848 subjects, of which 471 (55.4%) were males and 377 (44.5%) were females, aged between 14 and 30 years. In 323 subjects, orthopantomograms were taken for radiological evaluation using Demirjian's method, where one or more than one third molar was clinically missing. The total number of third molars in the study was 3392, out of which 1021 molars were clinically erupted in both maxilla and mandible and 2371 molars were missing in both maxilla and mandible.

Clinical evaluation of third molars results

The study showed that partially erupted third molars were encountered more often in the mandible (89) than in the maxilla (27) and mandibular third molars were missing more often in females than in males. The Pearson's Chi-square test with Yates continuity correction was used to calculate the *P* value for comparison of proportion between male and female subjects. The results showed that the *P* values were highly significant in both male and female subjects [Graph 1 and Table 1].

Figure 1: Clinically missing lower right third molar

Figure 2: Clinically erupted lower right third molar

Figure 3: Orthopantomograph of an adult female aged 19 years. The tooth germs of maxillary and mandibular third molars are visible (showing Demirjian formation stage D)

Table 2 shows that the mean age of having clinically completely erupted maxillary third molars was 22.41 years in male subjects and 23.81 years in female subjects. Statistically significant difference ($P < 0.05$) was obtained in maxillary third molars erupted and missing cases. This difference indicates that maxillary eruption sequence is earlier in males than in females [Graph 2].

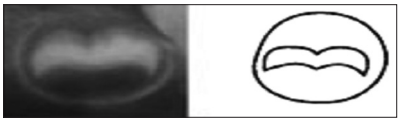
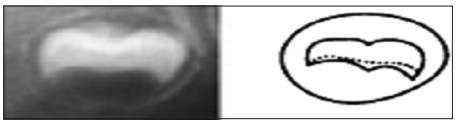
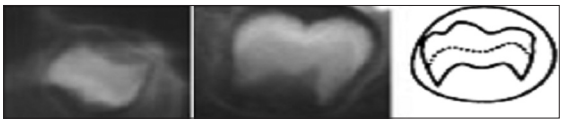
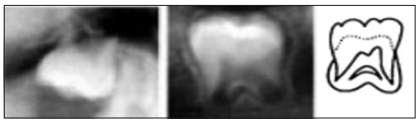
Stage A	Cusp tips are mineralized, but have not yet coalesced	
Stage B	Mineralized cusps are united; so the mature coronal morphology is well defined	
Stage C	The crown is about half formed, the pulp chamber is evident, and dentinal deposition is occurring	
Stage D	Crown formation is complete to the dentinoenamel junction. The pulp chamber has trapezoidal form	
Stage E	Formation of the inter-radicular bifurcation has begun. Root length is less than the crown length	
Stage F	Root length is at least as great as crown length. Roots have funnel-shaped endings	
Stage G	Root walls are parallel, but apices remain open	
Stage H	Apical ends of the roots are completely closed and the periodontal membrane has a uniform width around the root	

Table 1: Comparison of status of maxilla and mandible third molars in both sexes

Age group	Sex	Erupted	Partially erupted	Missing	Total	Test *P* value
Maxilla	Male	126 (26.8%)	16 (3.4%)	329 (69.9%)	471 (100%)	0.000 (*)
	Female	53 (14.1%)	11 (2.9%)	313 (83%)	377 (100%)	
Mandible	Male	81 (17.2%)	59 (12.5%)	331 (70.3%)	471 (100%)	0.000 (*)
	Female	32 (8.5%)	30 (8%)	315 (83.6%)	377 (100%)	

Table 2: Descriptive values and statistical comparison of clinical status in both sexes in the maxilla

Clinical status	Male			Female			Test *P* value
	N	Mean	SD	*N*	Mean	SD	
Erupted	126	22.41	4.23	53	23.81	4.00	0.038 (*)
Partially Erupted	16	18.44	1.15	11	18.82	2.4	0.633 (NS)
Missing	329	18.74	2.67	313	19.26	3.17	0.026 (*)

SD indicates standard deviation and NS, Not Significant; *$P < 0.05$

Table 3 shows that the mean age of having clinically completely erupted mandibular third molars was 21.49 years in male subjects and 23.34 years in female subjects. Statistically significant difference ($P < 0.05$) was obtained in mandibular third molars erupted cases. This difference indicates that mandibular third molars eruption sequence is earlier in males than in females [Graph 2]. For each group in this study, eruption of mandibular third molars was generally ahead of the emergence of maxillary third molars into the oral cavity.

Radiological evaluation of third molars using Demirjian's stages results

The third molar formation process was examined in both sexes, and the mean ages and standard

deviations for the Demirjian stages are presented in Tables 4 and 5.

Statistically significant differences ($P < 0.05$) were obtained in maxillary third molar development calcification stage F and stage G. These differences indicate that maxillary third molar eruption attained the Demirjian formation stages earlier in males than in females [Graph 3]. Statistically significant differences ($P < 0.05$) were obtained in mandibular third molar development calcification Stage F. These differences indicate that mandibular third molar eruption attained the Demirjian formation stages earlier in males than in females [Graph 3].

DISCUSSION

Third molars in humans are by far the most variable teeth with respect to size, shape, and formation. Third molars are also the only teeth to complete their formation after the onset of puberty and they exhibit an unusually long developmental course lasting more than 10 years. This late development has itself led to an interest in studying the formation of the third molars, since they are the only teeth that form during late adolescence and early adulthood.[6] This is the period when very few other skeletal–dental estimators of biological age are available for those concerned with growth or forensic applications.[7]

Various studies have been conducted around the world to assess the eruption sequence of the third molar in different populations.

Table 3: Descriptive values and statistical comparison of clinical status in both sexes in the mandible

Clinical status	Male			Female			Test
	N	Mean	SD	*N*	Mean	SD	*P* value
Erupted	81	21.49	3.95	32	23.34	4.34	0.041 (*)
Partially Erupted	59	20.78	4.47	30	19.57	3.18	0.144 (NS)
Missing	331	19.09	3.02	315	19.57	3.42	0.061 (NS)

SD indicates standard deviation and NS, Not Significant; *$P < 0.05$

Table 4: Descriptive values and statistical comparison of Demirjian's stages in both sexes in the maxilla

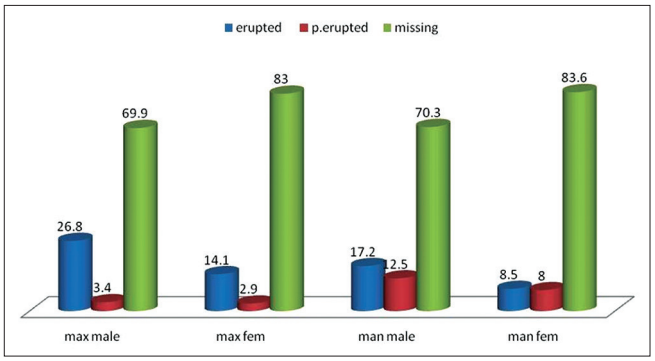
Demirjian's stage	Male			Female			Test
	N	Mean	SD	*N*	Mean	SD	*P* value
Stage D	23	17.96	2.637	40	19.55	3.515	.064 (NS)
Stage E	22	19.55	2.773	41	19.39	3.201	.848 (NS)
Stage F	38	20.03	2.696	45	21.29	2.777	.040 (*)
Stage G	13	19.38	2.534	20	22.45	2.819	.003 (*)
Stage H	17	22.88	3.789	23	23.35	3.157	.678 (NS)

SD indicates standard deviation and NS, Not Significant; *$P < 0.05$

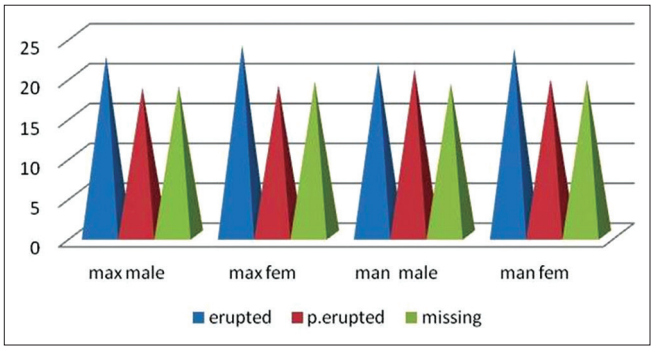
Table 5: Descriptive values and statistical comparison of Demirjian's stages in both sexes in the mandible

Demirjian stage	Male			Female			Test
	N	Mean	SD	*N*	Mean	SD	*P* value
Stage D	14	17.36	2.134	42	19.05	3.084	.063 (NS)
Stage E	23	18.39	2.017	36	19.22	3.172	.268 (NS)
Stage F	42	20.12	2.915	40	21.88	3.123	.010 (*)
Stage G	19	20.47	3.255	29	21.69	2.647	.162 (NS)
Stage H	18	22	3.395	32	22.53	3.455	.602 (NS)

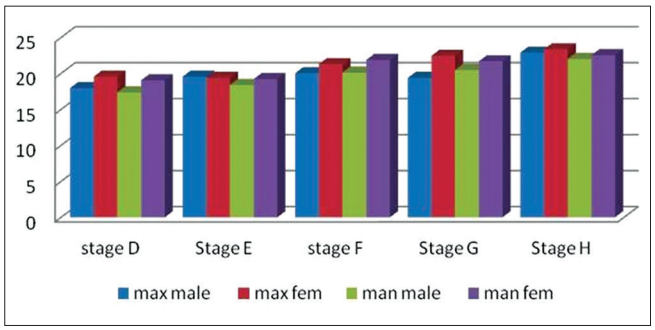
SD indicates standard deviation and NS, Not Significant; *$P < 0.05$



Graph 1: Comparing percentile for male and female for maxillary and mandibular third molars



Graph 2: Descriptive values and statistical comparison of clinical status in both sexes in the maxilla and mandible



Graph 3: Descriptive values and statistical comparison of Demirjian's stages in both sexes in the maxilla and mandible

In this study, it was attempted to evaluate the eruption status of third molars in Chennai population by clinical and radiological examination and also to find if there is any variation from other populations.

The present study results showed that the mean age of having clinically completely erupted maxillary third molars was 22.41 years in male subjects and 23.81 years in female subjects. Mandibular third molars had a mean age of completion of 21.49 years in male subjects and 23.34 years in female subjects. Odusanya *et al*.[8] concluded that the initial eruption of third molars was at 15 years and 13 years of age in male and females subjects, respectively, and the results are not consistent with the results of the present study. Soo-Hyun-Lee *et al*.[8] reported that the third molars in the Korean population were likely to begin erupting at age 7 years in both males and females and to be completed by age 22 years in males and 24 years in females. These results are in accordance with the present study.

In the present study, eruption of third molar was first seen first in the mandible followed by the maxilla. These results are not consistent with the results obtained by Irjaventa *et al*.,[9] Kasper *et al*.,[10] and Loredana Golovcencu *et al*.,[11] where they observed the eruption of third molar first in the maxilla followed by the mandible. These differences may be because of geographic and ethnic variations.

Chronologic age estimation by tooth development has been followed over a long period of time. The third molar calcification staging is one of the few tools that can be used to assess age when development is nearing completion.[12,13] In the literature, a variety of classifications have been put forward by different authors.[11,14,15] However, some of these classifications identify a large number of stages that are hard to distinguish from one another. Demirjian *et al*.[3] presented a classification distinguishing four stages of crown development (stages A–D) and four stages of root development (stages E–H). The system avoids any numeric identification of stages, so as not to suggest that a different stage represents processes of the same duration. The stages proposed by Demirjian *et al*. are defined by changes in shape, independent of speculative estimations of length.[12,13]

Classification of developmental stages by Nolla *et al*. and Moorress *et al*. is mainly based on numerical values and grading system. But in Demirjian's method, more than eight stages are there to compare with. Therefore, Demirjian's *et al*. method is the most appropriate for the present study.[12]

The radiological finding of our study indicates that the Chennai population reaches stage H at a mean age of 22.88 years in males and 23.35 years in females for maxillary third molars and a mean age of 22 years in males and 22.53 years in females for mandibular third molars.

Orhan *et al*.[10] found that Turkish population reaches stage H at a mean age of 20.1 years. On the other hand, another study performed by Yildiraysirman *et al*.[12] indicated that the Turkish population reaches stage H at a mean age of 22.1 years in males and 22.6 years in females. This is not consistent with the results of our study. The diversity could be explained by the differences in the selected age range of the study populations.

In the present study, third molar development between male and female subjects revealed statistically significant differences in calcification stage F and stage G in maxillary third molars and stage F in mandibular third molars ($P < 0.05$). These differences indicate that maxillary and mandibular third molar eruption reached these Demirjian's formation stages earlier in males than in females. This observation was not consistent with previous studies, which reported that the mean age at some of the developmental stages was lower for males than for females.[12,16]

Population differences in the body build, head form, and dentition are the result of genetic and environmental interactions. An appreciation of this genotype–phenotype relationship as a source of physical variation in humans is important in the recognition and establishment of correct standards for any given population.

The variation in Indians may be attributed to genetic, racial, socioeconomic, and maternal factors, which vary considerably between Indians and those from the rest of the world.[17]

As per the existing literature, Indians show a lower nutritional status as compared to westerners. This suggests that racial difference between the other populations is the main factor underlying the variations in eruption timings.[17-19]

So, this study reports a significant difference in the eruption timings of third molars in Chennai population when compared to other populations.

CONCLUSION

Teeth represent useful material for age estimation. The present study results also showed that the mean age of having clinically completely erupted of maxillary third molars was 22.41 years in male subjects and 23.81 years in female subjects and that of mandibular third molars was 21.49 years in male subjects and 23.34 years in female subjects. Mandibular third molars were clinically missing more often in females than in males. Eruption of mandibular third molars was generally ahead of the emergence of maxillary third molars into the oral cavity. Third molar development between male and female subjects revealed statistically significant differences at calcification stage F and stage G in the maxillary third molars and stage F in the mandibular third molars ($P < 0.05$). These differences indicate that maxillary and mandibular third molar eruption reached these Demirjian's formation stages earlier in males than in females. It is suggested that in future studies, to increase the accuracy of age determination, indications of sexual maturity and ossification should also be evaluated in addition to third molar mineralization. There are several factors which can hamper the eruption of third molars, such as bone covering and soft tissue covering, and these are not included in this study. Future studies should take this into consideration. The use of third molars as a developmental marker is appropriate, especially when comparing the obtained standard deviation with other skeletal age calculation techniques based on hand wrist or long bones.

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