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Original Research Article

Estimation of Age from Roentgenographic Study of Root Development of Mandibular Third Molars

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Article Info	Abstract

Background: Age estimation is important for identification of individuals as well as unknown skeletal remains. Estimation of radiological age is a matter of everyday occurrence in every part of the world. Determination of individual age is of great medicolegal importance in criminal cases as well as for civil purposes. Age estimation from teeth is generally reliable as they are naturally preserved long after all tissues and bones have disintegrated. A roentgenographic study was done to determine the age by root developmental changes using of the mandibular third molars, adopting the Leif Kullman method. **Material & Methods:** A total of 301 orthopantograms (OPG) were obtained from subjects from schools, colleges in the city and among the patients visiting the outpatient department of the teaching hospital and examined for the root development of mandibular third molars. In the end, out of 301 orthopantograms only 288 were taken into consideration for study purpose as in rest of the OPG third mandibular molar were found missing on both side. Based on stages of root development of third molar teeth, chronological age was determined. **Results & Conclusions:** There was a high correlation between the dental age & chronological age which plays an important role in medicolegal cases. The correlation of third molar development and chronological age is quite significant even though it is said to be the most valuable tooth in dentition.

1. Introduction

Age plays an important role in Forensic Medicine and is one of the prime factors employed to establish identity. Evidence of age for medicolegal purposes may be required in several types of cases. The usual cases wherein a medical man may be called upon to give his opinion with regards to age in routine medicolegal practice are infanticide, criminal responsibility, kidnapping, competency as a witness, eligibility for employment, professional and other courses, rape, judicial punishment, marriage contract, attainment of majority, criminal abortion, senior citizen concession, old age pensions, retirement disputes among many others.[1] It can be determined by developmental changes in skeletal bones and teeth.

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Like the radiographic or gross anatomical state of development and fusion of the skeletal bones, the stage of formation and the progress of age changes in teeth constitute another reliable source of information in determination of age of an individual.[2] Age estimation from dentition becomes difficult after 14 years since all the permanent teeth, except the third molar have completed their development. Eruption of third molars is most variable and controversial in dentition, but this is virtually the only biologic indicator available in the oral cavity for estimation of age by simple naked eye examination. Such a study of eruption and calcification of the third molar teeth has great medicolegal importance

A study of radiographs of teeth is a simple method to obtain dental information of an individual for age estimation of a person.[3] Though radiologically distinguishable stages of root formation are described rarely for age determination, most of these methods have their best precision and accuracy during early years of development of an individual. In present study estimation of age from roentgenographic study of root development of mandibular third molars using Leif Kullman's(1992) method was done which is considered to be a reliable guide to the determination of the age of an individual and also correlation between chronological age and dental age was studied. However, these values at their best can tend to fix the age of the person only at neat approximate age range and not the exact age.

2. Methods

The study consisted of 301 orthopantograms (OPG) out of which only 288 were taken into consideration for study purpose as in rest of the OPGs third mandibular molar were found missing on both side. The subjects were from school and colleges in Mumbai Central and patients who were visiting the Dental Surgery outpatient department in Nair Hospital, Mumbai Central, Mumbai. The selection criteria of the subjects were based on the following:

a. All subjects should be living in city region.
b. Subjects should be in the age group of 15-25 years with known date of birth as per valid age proof.
c. All subjects should be free from caries of teeth, should have good oral hygiene and normal intact teeth.
d. No evidence of malnutrition or other diseases that would affect the skeletal growth and general development of person.
e. Should voluntarily consent before proceeding for radiological examination

Informed consent was taken from each individual prior to examination in the prescribed format approved by the Institutional Ethics Committee of the college. Each participant was then subjected to OPG. Each of these digital OPG image were then studied for seven different stages of root development of the third molars by method adapted by Leif Kullman et al[4,5] for the reasons of simplicity and good results. The stages of root development are as follows:

- Ri-R1/4 (1): Root development initiated but<1/4 of the estimated root length.
- R1/4-R1/2 (2): Root development >1/4, but <1/2 of the estimated root length.
- R1/2 –R3/4 (3): Root development >1/2, but <3/4 of the estimated root length.
- R3/4 –Rc (4): Root development >3/4, but <full estimated root length.
- Rc-Aci (5): The full estimated root length is formed but apical closure not initiated.
- Aci-Ac (6): Apical closure started, but not closed.
- Ac (7): Apex is fully closed, and root development completed.

The chronological age of the person was also determined initially since the date of birth of the subject was known. Data was fed into Excel and analysed using SPSS Software. For assessing the correlation between the age determined by various methods and the chronological age, the Pearson's correlation coefficient was calculated, and its significance was tested by student's 't' test. "P" value of less than 0.005 was considered as significant.

3. Results

A total of 301 orthopantograms were obtained and examined for the root development of mandibular third molars. Out of 301 orthopantograms only 288 were taken into consideration for study purpose as in the rest of the OPG third mandibular molar were found missing on both side. **Table 1** shows the age and gender breakdown analysis of the number of subjects that had participated in the study. All the orthopantograms were studied and stages of root development of mandibular third molar on both the side were recorded. The age of each of individual in the study group was confirmed by their age document, entered in master chart, and converted into decimals while doing analysis.

A mean age was derived as the mathematical mean of age opined for each tooth individually, based on root developmental stages (Kullman) observed in the radiograph. In order to do a comparative

statistical analysis, common chronologic (true) age range was derived next for each of the root developmental stages by just noticing the lowest age and the highest age for a particular stage. Then a common mean age for each of the mandibular third molars was derived again calculating the mathematical mean of the common age range derived earlier which was depicted in **Table 2**. The difference in the age range determined by different developmental stages between almost all the left and right sided mandibular third molars was negligible as depicted in the table.

Table 1: Breakdown analysis by age and gender

Age Group as per DOB		Study Group		Total
		Male	Female	
15 to 17 yrs.	Count	15	19	34
	Percent	44.10%	55.90%	100.00%
17.1 to 19 yrs.	Count	47	51	98
	Percent	48.00%	52.00%	100.00%
19.1 to 21 yrs.	Count	73	66	139
	Percent	52.50%	47.50%	100.00%
21.1 to 25 yrs.	Count	20	10	30
	Percent	66.70%	33.30%	100.00%
Total	Count	155	146	301
	Percent	51.50%	48.50%	100.00%

Table 2: Comparative status of the common age range and mean age derived for each of the third molars for different stages of root development.

Stages	Right Mandibular		Left Mandibular	
	Age range	Mean	Age range	Mean
1	15 y-15y 9m	15y 3m	15y-15y 9m	15y 3m
2	16y-16y 9m	16y 4m	16y-16y 9m	16y 4m
3	16y 1m-17y	16y 9m	16y 1m-17y	16y 7m
4	17y 3m-17y 6m	17y 5m	17y 3m-18y 9m	17y 11m
5	17y 3m-20y 9m	17y 11m	17y 9m-20y 9m	18y 1m
6	17y 9m-21y 3m	18y 8m	17y 9m-21y 3m	18y 9m
7	18y 8m-24y 6m	20y 3m	18y 8m-24y 6m	20y 3m

**Table 4: Mean ages at attainment of stages of third mandibular molar development**

Gender	Male		Female		Mean of both sexes
Stages	Right	Left	Right	Left	
1	15.31	15.31	15.3	15.3	15.3
2	16.41	16.41	16.22	16.23	16.31
3	16.97	16.97	16.42	16.33	16.67
4	17.58	17.58	17.38	18.08	17.65
5	17.76	18.09	18.12	18.15	18.03
6	18.72	18.74	18.73	18.76	18.73
7	20.33	20.32	20.21	20.18	20.26

The study revealed that that differences in the mean age at the various stages of development of right and left mandibular third molar in both male and female subjects is negligible as shown in **Table 3.** It is also evident that difference in the mean age at the

various developmental stages in left and right mandibular third molar is negligible. It was observed that there was no significant difference between stages of development of right and left mandibular third molar in male as well as female as shown in **Table 4**.

From the **table 5** shown it is evident that there is no significant difference between the various stages of development of right and left mandibular third molar in male and female. A strong correlation was found between chronological age and dental development and third molar root development stages. Correlation coefficient and p value between dental parameter and chronological age were derived statistically as depicted in **Table 6**. Age determined by dental parameters is correlated with the chronological age as confirmed by the p value.

Graph 1: Correlation between dental age and chronological age
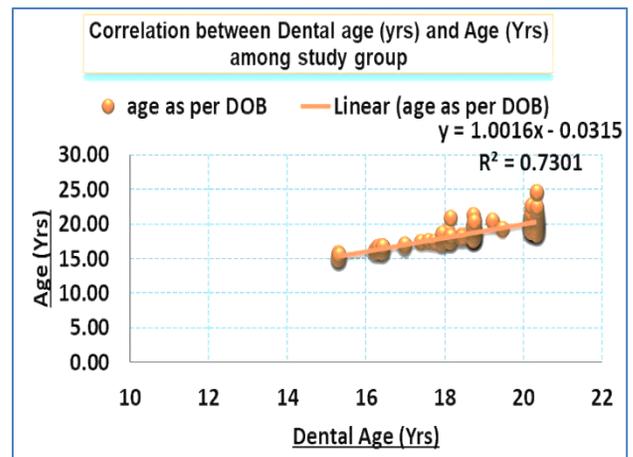
Linear regression coefficient (Pearson Correlation) is provided to assess the correlation between the third molar development and chronological age. Statistical analysis showed a strong correlation between various stages of third molar development and chronological age (**Graph 1**).

Each stage of root development of third molar strongly correlates with certain age group i.e. if we have a tooth in particular stage of development the age can be derived with reasonable accuracy.

The formula to derive the age from root development stage (Regression formula) can be stated as follows:

Decimal age in years

= 1.0016 (Age in decimal of developmental stage of mandibular left / right third molar) – 0.0315.

4. Discussion

In forensic dentistry, determination of dental age using stages of tooth development to gauge an individual's degree of maturity is one of few biological

Table 3: Mean ages at attainment of stages of mandibular third molar development and gender wise distribution of both sides

	Male: Right Mandibular Region				Female: Right Mandibular Region				Mandibular Right			
Stage	Count	Age as per DOB (decimal)			Count	Age as per DOB (decimal)			Count	Age as per DOB (decimal)		
		Minimum	Maximum	Mean		Minimum	Maximum	Mean		Minimum	Maximum	Mean
0	6	18.33	21.00	19.51	16	15.33	22.33	18.33	22	15.33	22.33	18.65
1	3	15.17	15.50	15.31	7	15.00	15.75	15.30	10	15.00	15.75	15.30
2	9	16.00	16.75	16.41	5	16.00	16.58	16.22	14	16.00	16.75	16.34
3	3	16.92	17.00	16.97	2	16.08	16.75	16.42	5	16.08	17.00	16.75
4	1	17.58	17.58	17.58	2	17.33	17.42	17.38	3	17.33	17.58	17.44
5	7	17.25	18.58	17.76	13	17.58	20.83	18.12	20	17.25	20.83	17.99
6	42	17.75	21.33	18.72	37	18.00	20.33	18.73	79	17.75	21.33	18.72
7	84	18.67	24.58	20.33	64	19.00	22.67	20.21	148	18.67	24.58	20.28
	Male: Left Mandibular Region				Female: Left Mandibular Region				Mandibular Left			
Stage	Count	Age as per DOB (decimal)			Count	Age as per DOB (decimal)				Age as per DOB (decimal)		
		Minimum	Maximum	Mean		Minimum	Maximum	Mean		Minimum	Maximum	Mean
0	5	18.17	21.00	19.38	13	16.17	22.33	18.28	18	16.17	22.33	18.59
1	3	15.17	15.50	15.31	8	15.00	15.75	15.30	11	15.00	15.75	15.30
2	9	16.00	16.75	16.41	4	16.00	16.75	16.23	13	16.00	16.75	16.35
3	3	16.92	17.00	16.97	3	16.08	16.58	16.33	6	16.08	17.00	16.65
4	1	17.58	17.58	17.58	2	17.33	18.83	18.08	3	17.33	18.83	17.92
5	8	17.25	20.42	18.09	12	17.58	20.83	18.15	20	17.25	20.83	18.13
6	42	17.75	21.33	18.74	39	18.00	20.42	18.76	81	17.75	21.33	18.75
7	84	18.67	24.58	20.26	65	19.00	22.67	20.18	149	18.67	24.58	20.26

Table 5: Stage wise gender distribution of mean ages at attainment of stages of right and left molar development in mandible

		RIGHT						LEFT					
Stage	Chronological Age (yrs)	N	Mean	Std. dev.	Unpaired T test	P value	Difference	N	Mean	Std. Deviation	Unpaired T test	P value	Difference
1	Male	3	15.31	0.17347	0.045	0.965	not significant	3	15.31	0.17347	0.021	0.983	not significant
	Female	7	15.30	0.27579				8	15.30	0.25564			
2	Male	9	16.41	0.29001	1.237	0.240	not significant	9	16.41	0.29001	0.959	0.358	not significant
	Female	5	16.22	0.24721				4	16.23	0.35600			
3	Male	3	16.97	0.04811	2.213	0.114	not significant	3	16.97	0.04811	4.347	0.012	not significant
	Female	2	16.42	0.47140				3	16.33	0.25000			
4	Male	1	17.58	.	2.887	0.212	not significant	1	17.58	.--	-0.385	0.766	not significant
	Female	2	17.38	0.05893				2	18.08	1.06066			
5	Male	7	17.76	0.48693	-1.013	0.324	not significant	8	18.09	1.04125	-0.120	0.905	not significant
	Female	13	18.12	0.84405				12	18.15	0.88272			
6	Male	42	18.72	0.69236	-0.087	0.931	not significant	42	18.74	0.68905	-0.173	0.863	not significant
	Female	37	18.73	0.67140				39	18.76	0.70991			
7	Male	84	20.33	1.14432	0.709	0.479	not significant	84	20.32	1.15033	0.853	0.395	not significant
	Female	64	20.21	0.74696				65	20.18	0.75993			

Table 6: Correlation between age determined by dental parameter and chronological (true) age

		Age as per DOB	Mandibular region Right	Mandibular region Left
Age as per DOB	Pearson Correlation		0.696	0.744
	P value		0.000	0.000
	Correlation is		Significant	Significant
Mandibular region Right	Pearson Correlation	0.696		0.738
	P value	0.000		0.000
	Correlation is	Significant		Significant

Mandibular region Left	Pearson Correlation	0.744	0.738	
	P value	0.000	0.000	
	Correlation is	Significant	Significant	

methods for monitoring physiologic development, and the dentition arguably is the only system available from prior birth to early adulthood. [6]

Dental development can also be used to estimate chronological age, such as, age at death of an unidentified person or the age of a suspect without legal documentation.[7] Younger ages can be assessed at greater accuracy because the intervals between morphological stages are shorter and therefore more precise.[8] Late in adolescence, after formation of the premolars and canines, only third molars continue to form source of age estimation. Third molars are in many respects the most variable teeth in the dentition.[9,10]

Chronological age estimation by tooth development has been used over long period. Tooth development is an accurate measure of chronological age that seems to be an independent of exogenous factors such as disease or malnutrition.[11] However age estimation based on dental methods have shortcomings especially during adolescence when the third molar is the only remaining variable dental indicator. Indeed, great variation in position, morphology, and time of formation exists. The difference between populations, the different methodology, and the dissimilarities among observers are the other shortcomings.

The single most compelling reason to rely on third molar development to estimate chronological age is that there are very few available alternative methods during the interval roughly between the mid-teens and early 20s. All of the other teeth have erupted and completed root formation.[11,12] All of the hand-wrist bones have achieved their adult morphologies, their epiphyses have fused,[13,14] and the onset of secondary sex characteristics has occurred. Consequently except for the ossification of same early fusing cranial and post axial sutures which themselves are quite variable-there are no other biological criteria by which estimation of chronological age is possible.

The third molar is far from being considered as an ideal development marker. It frequently is congenitally absent,[15,16] malformed,[17] impacted or extracted. Further, it is the most variable tooth in the dentition as regards size,[18,19] time of formation and time of eruption.[20] It is not surprising then that the

association between chronological age and formation of the third molar is moderate. Nevertheless, it offers a unique advantage over other teeth in that its development tends to continue over a long period and until a later age.[21]

For medicolegal purposes, the age of 18 years is an important cut-point, but other ages (for e.g., 21 years) could be used just as easily. If a subject presents with a third molar root developmental stage anywhere between 1 and 5, there is likelihood that he or she has not attained the age of 18 years. At the other end, if the root apices are closed (Stage 7) one can be reasonably confident that the subject is indeed at least 18 years of the age.[4]

An important caveat needs reemphasis. Stage 7 (apex closed) occurs in all mature third molars regardless of age. Consequently, the age estimates for this terminal grade assume that independent criteria can be used to exclude subject over 24 years of age. The onset of root maturity in the third molar (Stage 7) is a valuable developmental event; it is the one marker in this tooth indicating that an individual is quite likely to be at least 18 years of age.[7]

In present study 155 (51.50%) boys and 146 (48.50%) girls of the age range 15-25 years from various schools and colleges and patients visiting the outpatient department of university teaching hospital were examined roentgenographically.

Demirjian,[11] Garn et al,[20] claim that tooth development is an accurate measure of chronological age that seems to be independent of exogenic factors like disease, malnutrition etc. Koshy and Tandon[22] study based on the Demirjian concluded that this method was not applicable for South Indian children due to wide ethnic difference. Similar kind of study is conducted by using Kullman's [23] method and findings were significantly accurate. Thus, we can say that when a particular method is applied for particular population then more accurate results could be obtained.

In present study no significant difference could be observed between different stages of root development, though boys were ahead of girls. These results are similar to Garn[20], Engstrom et al,[21] and Bhat Vrinda[24]. But these findings are in contradiction to Kullman et al[4] who found significant sex difference in stages of root development.

In present study, age determined by dental parameters is correlated with the chronological age as confirmed by the p value. However, age which was determined by the left mandibular third molar was found to have highest association with chronological age which was consistent with Bhat Vrinda.[25] Sumbh et al[26] used Kronfeld's method in analysis of age estimation cases using OPG. Some researchers used other methods for age estimation.[27-30]

In the present study the mean ages for the third molar developmental stages are in the same range mentioned by Kullman [23] i. e. between 15 years to 20 years. Overall, a strong correlation was observed in between third molar development and chronological age.

5. Conclusions

It can be concluded that a strong correlation was observed in the present study between third-molar development and chronologic age. The correlation of third molar development and chronological age is quite significant even though it is said to be the most valuable tooth in dentition.

Situations may arise when malnutrition or other environmental factors have influenced the somatic development of an individual. In such cases, the third molar was found to be useful in assessing chronological age as its independent of such factors. However, various studies need to be conducted in other region in order to verify the accuracy in other study populations over the country.

6. Limitation

1. This method cannot be employed if molars are absent (not formed at all)
2. Not practicable if dental X-ray services are not available.
3. Possibility of observer's error in staging of 3rd molar development.

List of abbreviations

OPG- Orthopantogram

Ethical Clearance: IEC approval was taken from the Institutional Ethical committee.

Contributor ship of Author: All authors equally contributed.

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