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RESEARCH ARTICLE

AGE ESTIMATION BY DENTAL RADIOGRAPH- A REVIEW STUDY

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ABSTRACT

Estimation of age of an individual whether living or dead is a subject of great medico legal importance and is the necessity for the purpose of administration of justice. Perhaps it is the second commonest medico legal problem after trauma. In our study, 610 orthopantomograms of individuals (292 males and 318 females) with known age and gender were evaluated. The age ranged between 7-21 years. Third molars are the teeth with the highest variability concerning anatomy, agenesis and age of eruption. Age estimation for medicolegal purposes by means of third molar development is used in the age between 14-21 years when all other permanent teeth have finished their formation. According to the recommendations of the interdisciplinary Study Group on Forensic Age Diagnostics, it is suggested to use Demirjian's developmental stages for third molar mineralization analysis. It can be concluded, that in the case where two mandibular molars are present, the probability for an Indian individual to be at least 18 years is 99.5 or 99.3% for males and females, respectively in the case were tooth mineralization is completed (Demirjian's stage H).

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INTRODUCTION

Estimation of age of an individual whether living or dead is a subject of great medico legal importance and is the necessity for the purpose of administration of justice. Perhaps it is the second commonest medico legal problem after trauma. Estimation of age is a role that a forensic practitioner often has to play, particularly in developing countries like ours for solving both civil as well as criminal matters like, Marriage, Identification, Criminal responsibility, Rape etc. Age estimation in living individuals is a team work of forensic physician, dentist, radiologists and anthropologist for quality assurance in this area and many countries like Germany the interdisciplinary "study group for forensic age estimation" was constituted in Berlin on March 10, 2000. The teeth are considered a reliable indicator of age and provide a number of parameters for age prediction, and traditional methods of adult dental age estimation require tooth extraction and processing. While extracting normal healthy teeth, unless indicated, is unethical and not practical in living individuals, it may not be permitted even in the deceased when preservation of human remains is deemed essential for a variety of legal and cultural reasons; on the other hand tooth processing has the added disadvantage that it necessitates destruction of dental evidentiary material. Radiographic evaluation of teeth requires neither tooth extraction nor processing; in post-mortem scenarios, teeth can easily be radio graphed using apparatus readily available in most mortuary settings. Importantly, dental radiography is also applicable to the living owing to miniscule radiation exposure. These reasons prompted the development of dental radiographic methods for adult age estimation.

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MATERIALS AND METHODS

In our study, 610 orthopantomograms of individuals (292 males and 318 females) with known age and gender were evaluated. The age ranged between 7- 21 years. The investigated radiographs were taken from the archives of the Department of Forensic Medicine and Department of Radio Diagnosis & Imaging, Institute of Medical Sciences, Banaras Hindu University, Varanasi between 2007 to 2012. Radiographs with optimum density and contrast were included in the study and those with any pathology, magnification and distortion were excluded.

One researcher evaluated each image according to patient positioning, head alignment and film density and contrast to avoid radiographs with distortion. Radiographs were coded to ensure that examiners were blind to sex, name, and age of subjects. All orthopantomograms were evaluated under

standardized conditions. The developmental stages were rated by two observers. Intraexaminer reliability was tested by repeating evaluations of 300 orthopantomograms at an interval of 10 days.

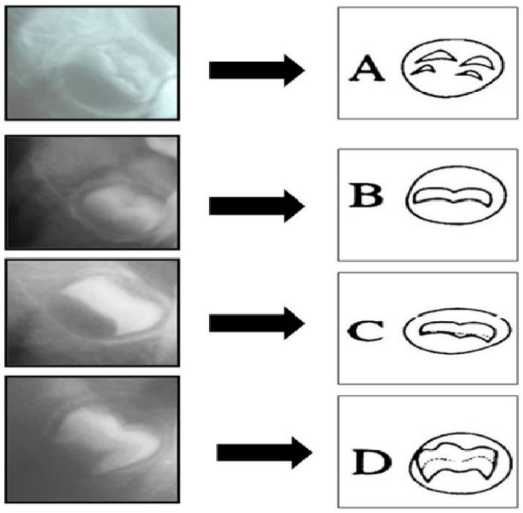
To assess the developmental stages of third molars from the mandible, modified Demirjian's classification system was adopted. Eight stages (from "A" to "H") plus "0", indicating the case of absence, were recorded for each subject. The Inter and intra-observer reliability were determined using the Wilcoxon matched-pairs test and the results were considered significant if $P < 0.05$. Comparisons between genders and between both sides were obtained using the Mann-Whitney U test and Wilcoxon test, respectively. Regression analysis was performed to obtain regression formulae for dental age calculation.

Observation

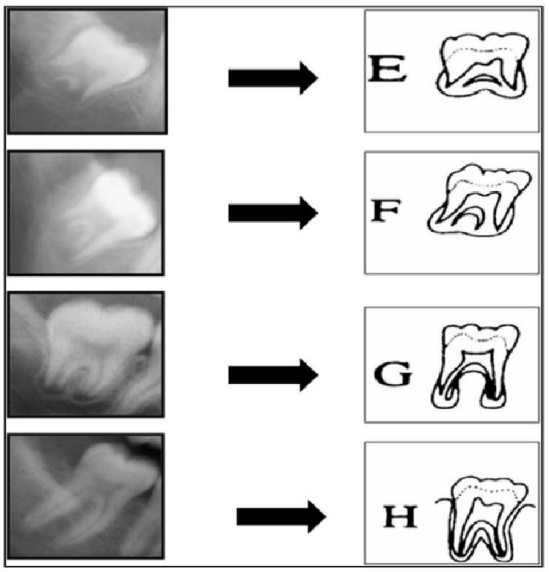
Developmental stages of third molars (modified demirjian's classification system)

Stage A: Cusp tips are mineralized but have not coalesced (Fig.1).
Stage B: Mineralized cusps are united so the matured coronal morphology is well defined (Fig.1).
Stage C: The crown is about half formed and the pulp chamber is evident and dentinal deposition is occurring (Fig.1).
Stage D: Crown formation is complete to the dentinoenamel junction. The crown is about half formed and the pulp chamber is trapezoidal form (Fig.1).
Stage E: Formation of the inter-radicular bifurcation has begun. Root length is less than the crown length (Fig.2).
Stage F: Root length is at least as great as crown length. Roots have funnel-shaped endings (Fig.2).
Stage G: Root walls are parallel, but apices remain open (Fig.2).
Stage H: Apical ends of the roots are completely closed, and the periodontal membrane has a uniform width around the root (Fig.2).

STAGES A – D (Fig.1)



STAGES E - H (Fig.2)



Demirjian *et al*. (1973, 1976) defined 4 developmental crown and 4 developmental root stages which were based on the appearance of the radiological visible tooth germ. In this approach a scoring system was used for the formation of 7 (or 4) left mandibular teeth. Every stage was assigned to a certain dental score. Adding up all scores gave the Dental Maturity Score which constitutes an indicator for an individual's dental maturity. The authors provided percentile distributions where the dental maturity score can be converted into an estimate of the subject's chronological age.

Third molars are the teeth with the highest variability concerning anatomy, agenesis and age of eruption. Age estimation for medicolegal purposes by means of third molar development is used in the age between 14-21 years when all other permanent teeth have finished their formation. According to the recommendations of the interdisciplinary Study Group on Forensic Age Diagnostics, it is suggested to use Demirjian's developmental stages for third molar mineralization analysis (Schmeling *et al*., 2004). Demirjian's stages have the advantage of being clearly defined with radiographs, diagrams, and written criteria. This was also confirmed by a direct comparison of 5 common classification systems on orthopantomograms of females aged 12 to 25 years (Olze *et al*., 2005). The use of Demirjian's stages showed the best inter-observer agreement and was found to have the strongest correlation between the age estimate and true age followed by the classification of Kullman *et al*. (1992).

A well-known study on third molar development was published by the American Board of Forensic Odontologists (Mincer *et al*., 1993) who used Demirjian's developmental stages to assess the mean ages of attainment. Unfortunately the study is weakened by the diversity of its sample which suggests that this data should not be used in practice. A detailed study on ethnical differences in third molar mineralization was published by Olze *et al*. (2004b) who evaluated more than 3.000 conventional orthopantomograms. It was shown that Japanese, German, and South African individuals differ up to

several years in reaching the respective developmental stage according to Demirjian. Therefore it is recommended to use populations-specific data in age estimation to guarantee for optimal reproducibility and feasibility of the evaluation.

These differences indicated that third molar genesis attained the Demirjian formation stages earlier in males than in females. The linear regression coefficients were provided to assess the correlation of third molar development and chronologic age. Statistical analysis showed a strong correlation between right and left side third molar development for females (r=0.86) than males (r=0.79) as depicted in Table 1. Regression formula for whole sample and for males and females separately, based on the number of third molar teeth present, were calculated. The following regression equations were derived:

Whole sample: Age =10.0215 + 0.5217 (DS Right) + 0.6703(DS Left)

Males: Age = 9.7139 + 0.6176 (DS Right) + 0.5935 (DS Left)
Females: Age = 10.2870 +0.4046 (DS Right) + 0.7704 (DS Left)

Table 1. Correlation between right and left third molars for males and females

GENDER	N	r	p Value
Male	144	0.7943**	0.00
Female	156	0.8636**	0.00

Figure 3 details the absolute and relative numbers of mandibular third molars in the Indian sample. Both sexes were pooled for this analysis, because it was not possible to exclude individuals with previous extractions. 477 (78.2%) out of 610 individuals possessed both lower molars. One mandibular third molar was recorded in 69 (11.3%) individuals; no lower molars were recorded in 64 (10.5%) cases.

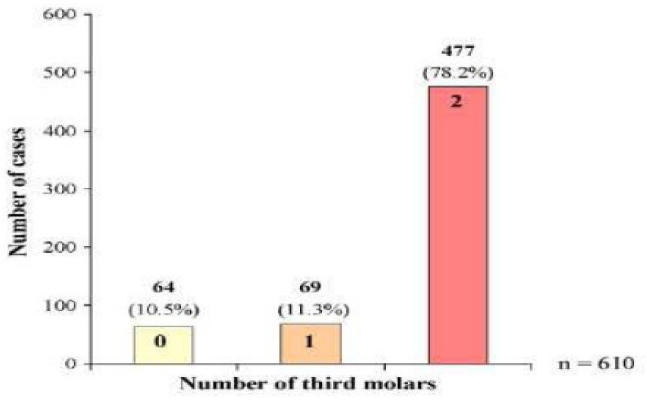


Fig. 3. Number of mandibular third molars

Based on Demirjian's stage H, Table 2 expresses the likelihood of an Indian being at least 18 years of age. The likelihood of an individual to have reached adult status with fully developed mandibular wisdom teeth amounts 99.5% for males and 99.3% for females. Additionally, one individual of the male subsample (out of 105 cases) and one individual of the female subsample (out of 74 cases) were found to present complete root formation of tooth 38 before their 18th birthday. Respectively, all orthopantomograms showed a completed root formation of tooth 48 at 18 years of age or more (105 males, 72 females). FDI system uses two digit numbers which refer to different teeth in different quadrants. Here, 38 denote left mandibular 3rd molar and 48 denote right mandibular 3rd molar.

Table 2. Likelihood of an Indian individual being over 18 years of age based on Demirjian's stage H

	Male	Female
48	100.0	100.0
38	99.1	98.7
Mean	99.5	99.3

DISCUSSION

We took 610 random cases from different schools, colleges and OPDs of Department of Forensic Medicine and Department of Radio Diagnosis & Imaging, Institute of Medical Sciences, Banaras Hindu University, Varanasi. Out of these 292 were males and 318 were females. We noted eruption of temporary and permanent teeth in the various age groups. In our study, we have choosen Demirjian's method as it is more simplified and the numbers of stages are restricted to avoid confusion while rating the teeth. Right – Left symmetry in development stage females (r = 0.86) showed a highest correlation coefficient than males (r = 0.79) and the findings were in harmony with that obtained by Mincer *et al*. (1993), Wilershausen *et al*. (2001), Solari and Abramovitch (2002). Our study also yielded the formulation of regression equations for age prediction of males, females and total subjects using different developmental stages of the wisdom teeth, obtained from examination of panoramic radiographs as,

Y = a+ b X1 + c X2.

Y- age; a, b, c - constant. X1- developmental stage of right mandibular third molar, X2- developmental stage of left mandibular third molar. Developmental stages of mandibular third molar tooth are expressed by numbers as follows: stage A = l, stage B = 2, stage C = 3, stage D = 4, stage E = 5, stage F = 6, stage G = 7 and stage H = 8. Various studies have been conducted in Indian population in different regions, only few of them (Balwant Rai, 2008; Rajan, 2010; Panchbhai, 2011) gave an acceptable estimate of chronological age. Our study also yielded acceptable age estimation. The availability of regression formulae will be helpful in forensic investigations regarding the determination of age.

The male and female data were pooled to evaluate the frequency of mandibular third molars, because sufficient data about possible previous extractions of the individuals was not available. Therefore, it was focused on the determination of the number of individuals who can be evaluated by the presence of their mandibular wisdom teeth. Thus, 477 individuals or 78.2%

of the Indian population can be evaluated by 2 radiological observable mandibular third molars. 69 individuals (11.31%) showed only one, 64 (10.5%) no third molar.

The results of this study show a faster development of third molars in Indian males than females and did not differ from findings of previous studies (Olze *et al.,* 2004; Ganss *et al.,* 1993; Levesque *et al.,* 1981; Mincer *et al.,* 1993; Prieto *et al.,* 2005; Thorson and Hagg, 1991; Arany, 2004; Kohler, 1994). This is a unique trait of third molars which expresses the sexually dimorphic character of tooth formation. Levesque *et al*. (2005) demonstrated that Franco-Canadian males are reaching Demirjian's stages earlier than girls beginning with stage F. Prieto *et al*. (2004) found a significant sexual dimorphism in stages E to G with males reaching the stages described by Demirjian *et al*. (1973) earlier. In the Japanese Population investigated by Arany *et al*. (2004), males entered the stages earlier than females; a significant gender difference was observed in the stages D, E and G. In line with these findings are reaching male individuals of the Indian population the root formation stages (E-H) earlier than females. A significant difference was found in the stages E and F.

According to the results of previous studies, Demirjian's developmental stage H could serve as a useful developmental marker to answer the question whether an individual is already considered as an adult. This stage marks the easy recognizable, fully mineralized tooth with apex closure. Therefore, the probability for an individual being older than 18 years was determined (Table 2). The calculated percentages indicate the degree of confidence whether a person has reached the age of 18 years. In the present sample, only two cases being younger than 18 years of age at the Demirjian's stage H were detected. The analysis showed, that the finished third molar mineralization indicates that the probability that an Indian individual is at least 18 years old, is 99 % certain.

Conclusion

It can be concluded, that in the case where two mandibular molars are present, the probability for an Indian individual to be at least 18 years is 99.5 or 99.3% for males and females, respectively in the case were tooth mineralization is completed (Demirjian's stage H). These results indicate that Demirjian's stage H might constitute a helpful marker in age estimation for medicolegal purposes; nonetheless wisdom tooth mineralization can always only be seen as just one detail in the interplay of structural changes during human growth.

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Conflict of Interest

Nil

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Ethical clearance

The present study was approved by "Institutional Ethical Committee" of Institute of Medical Sciences, Banaras Hindu University, Varanasi. All the information has been taken under consideration of medical ethical committee.

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