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Medicolegal Study of Age by Dental Radiograph

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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. The study was conducted during the period of September 2007 to September 2012 and 610 cases were studied which were taken randomly from various schools, colleges and OPD's of Department of Forensic Medicine and Department of Radio Diagnosis & Imaging, Institute of Medical Sciences, Banaras Hindu University, Varanasi. Attrition method is the best clinical method where the attrition of molar cusps is recorded. This method is suitable for Indian population. It can be concluded, that above methods of age estimation can be tried in forensic cases in the identification of the individual with no birth records. Expertness and the combination of physical examination of the suspect, dental examination which records dental status including OPG, x-ray examination of the left hand and wrist and radiographic or CT survey of the clavicle lead to conclusions regarding the estimated age.***

Keywords: Orthopantomograms, Gustafson's stages, Forensic Age Diagnostics, mandibular molars

1. 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, where many births take place in rural settings, without the benefits of expert supervision by a trained obstetrician. Such birth are poorly recorded or more often not recorded at all in terms of exact dates. In many other cases, records are fraudulently falsified with the prospect of financial gain e.g. to obtain government post or pensions. The growing cross –border migration, case of refugees /asylum seekers, which has led to an increase in the no. of foreigners who can't present documentary evidence for the date of birth. As a result of this development, forensic medicine is more and more confronted with the problem of age estimation in living individual involved in penal proceedings. 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.

Age estimation in living individual is important for solving both civil as well as criminal matters:

Civil cases: Marriage, Employment, Impotency and sterility, Competency as a witness, Identification, Concession, Retirement benefits, In old persons for question of fitness and government pensions schemes.

Criminal cases: Rape section (375 IPC), Kidnapping (section 361,366 A, 366B, 369 IPC), Criminal responsibility, Juvenile delinquency etc.

Gustafson has estimated the age of an individual above twenty-five years by six stages of attrition, peridontosis, secondary dentine formation, root resorption, root transparency and cementum apposition. Gustafson combined 6 age-dependent variables (attrition, periodontal attachment, secondary dentin, cementum apposition, root resorption, root dentin transparency) for age estimation carried out on longitudinally ground sections (Gustafson 1950).

2. Material and Methods

The scientific basis of age estimation is the genetic control of "ontogenesis", which delimits the temporal variation of developmental stages. The growth curve of monozygotic twins shows a high degree of correspondence. Matching of skeletal age development corresponding with the chronological age is the aim of age estimation. Although a range of diagnostic procedures are available for the age estimation, but only a few of these appear to be suitable for forensic application in living individuals. There is wide agreement about the most suitable methods presently available. These are:

1. Physical examination with determination of anthropometric measures (height & weight, constitutional type) inspection of the signs of sexual maturation and identification of any developmental disorders that might affect age appropriate development.
2. Examination by a dentist with determination of the dental status and X-ray study of dentition.
3. Radiological examination of appearance of ossification centers and fusion of epiphysis.

These methods should be used together to increase the diagnostic accuracy. With increase in age the reliability of parameters and accuracy of age determination decreases, so to overcome that CT scan and Biochemical methods are also done for better results.

3. Observations

The study was conducted during the period of September 2007 to September 2012 and 610 cases were studied which were taken randomly from various schools, colleges and OPD's of Department of Forensic Medicine and Department of Radio Diagnosis & Imaging, Institute of Medical Sciences, Banaras Hindu University, Varanasi.

Table 1: Showing Distribution of Cases According to Sex and Age

Age group	Male	Female	Total no. of cases
0.5 - 4 years	62	60	122
4.1- 9 years	61	68	129
9.1-14 years	51	60	111
14.1-19 years	64	59	123
19.1-25 years	54	71	125
Total	292	318	610

This table shows distribution of cases among males and females. In each group a minimum of 50 males and 50 females are taken.

Table 2: Showing Distributions of Cases for Eruption of Temporary Teeth According to Age and Sex

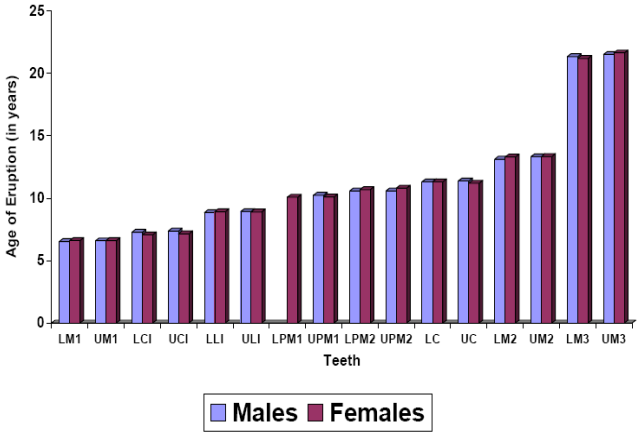
Age group (Months)	Male	Female	Total no. of cases
6 – 12	33	25	58
12.1 – 24	23	20	43
24.1 – 33	11	12	23
Total	67	57	124

Table 2 shows that a total of 124 cases are taken for eruption of teeth out of which 67 are males and 57 are females.

In Table 3, the range and mean age of eruption of temporary teeth has been analyzed. It has been observed that there was no significant difference in the right and left teeth of upper jaw as well as lower jaw of different types of teeth.

Table 3: Showing Range and Mean Age of Eruption (In Months) of Temporary Teeth

Type of Tooth	Jaw	Side	No. of cases	Range	Mean ± S.D.	Stat. Sig.
Central Incisor	UJ	R	6	8.28-11.04	9.48 ± 0.96	P>0.05 NS
		L	6	8.28-11.04	9.48 ± 0.96	
	LJ	R	9	6.60-9.36	8.28 ± 0.84	P>0.05 NS
		L	9	6.60-9.36	8.28 ± 0.84	
Lateral Incisor	UJ	R	12	8.88-13.08	10.20 ± 1.08	P>0.05 NS
		L	12	8.88-14.28	10.56 ± 1.56	
	LJ	R	12	8.88-15.96	13.20 ± 2.28	P>0.05 NS
		L	12	8.88-15.96	13.20 ± 2.28	
Canine	UJ	R	21	17.40-21.84	19.20 ± 1.44	P>0.05 NS
		L	21	17.40-21.84	19.20 ± 1.44	
	LJ	R	19	17.40-21.84	19.32 ± 1.56	P>0.05 NS
		L	19	17.40-21.84	19.32 ± 1.56	
M_1	UJ	R	5	14.64-16.56	15.84 ± 0.72	P>0.05 NS
		L	4	14.64-16.56	15.56 ± 0.72	
	LJ	R	7	13.08-16.56	15.12 ± 1.32	P>0.05 NS
		L	7	13.08-16.56	15.12 ± 1.32	
M_2	UJ	R	25	20.88-32.16	27.72 ± 3.36	P>0.05 NS
		L	25	20.88-32.16	27.72 ± 3.36	
	LJ	R	27	20.88-32.16	27.72 ± 3.36	P>0.05 NS
		L	27	20.88-32.16	27.72 ± 3.36	



Graph 1: Showing Distribution of Age to Eruption of Permanent Teeth in Relation to Sex of the Person

4. Results and Discussion

Physical Development and Secondary Sexual Characters:

1. Secondary sexual characteristics only give a very vague idea of age and are obviously not very helpful from a medicolegal angle.
2. Sometimes, however, they can provide good corroborative evidence.
3. Hair first appears around the pubes, then in the axilla and finally over the face.

4. In males- fine, downy pubic hairs appear around 14 yr and in the axilla by 15 yr, and on the chin and upper lip between 16- 18 yr.
5. Hair on the inner sides of thigh and on the scrotum may appear after 18 yr.
6. The Adam's apple becomes more prominent by 16-18 yr.
7. In females the order of development is – Thelarche (11-12yr) → Pubarchy (12-13yr) → Menarche (13-14yr) Of course there may be variation of age in different persons.

Examination by a dentist with determination of the dental status & x-ray study of dentition-Although the science of forensic odontology has emerged near its height at the global level, this specialty has not developed or evolved as a subject in India.

Determination of age from dentition in children:

1. At birth, the rudiments of all temporary teeth and 1st permanent molars are there.
2. In children and young person's the chronological calcification and eruption of teeth gives their ages.
3. Temporary and permanent teeth- there are two sets of teeth- temporary and permanent
4. By the age of 2½ to 3 yr, the temporary set is complete. there are 20 temporary teeth i.e.. 2 incisors, 1 canine and 2 molars in each quadrant of the jaw (2102/ 2102).
5. At the age of 6, the first permanent tooth- the 1st molar erupts. Gradually the permanent set replaces the temporary set.
6. The permanent teeth are 32 in number and comprise of 2 incisors, 1 canine, 2 premolars and 3 molars in each quadrant of the jaw (2123/ 2123).
7. "Wisdom tooth" – the last permanent tooth to erupt is the 3rd molar. It erupts between 18-25 yr.
8. The permanent incisors, canine and premolars are also known as "success ional permanent teeth".
9. These are called so because they come in succession to temporary teeth. The permanent molars are the 'superadded' teeth. These are called this because they are added over and above the teeth already present. They do not replace any teeth.
10. The 2nd permanent incisor replaces the 2nd temporary incisors. The 1st permanent canine replaces the 1st temporary canine. The 2nd permanent premolars replace the 2nd temporary molars.
11. The 3rd permanent molars do not replace any teeth.
12. The molars arrive in a mathematically beautiful rhythm- at 6, 12, and 18 to 24. Thus the total number of teeth would change only at these ages.

Mixed Dentition

1. Mixed dentition is the period when both the temporary and permanent teeth are present in the jaw.
2. It is the period starting from 6th yr of life when the 1st molar erupts and till the 2nd permanent molar erupts ie. 12 yr.
3. between 6-11 yr is the period of mixed dentition, during this period age of the child can be easily calculated by the formula-(Age in yr – 5) X 4 = no. of permanent teeth in the mouth
4. Impacted teeth- in some individual, the 3rd molar never erupts in oral cavity as the jaw space is inadequate. This is seen particularly in mandibular 3rd molar that remains trapped and is called impacted teeth.
5. A panorex view immediately enables a medico legal specialist to tell which of the teeth are deciduous and which are permanent, erupted or un-erupted.
6. This is relatively new method of taking dental radiograph. Originally the technique was called the orthopantomograph (OPG). However its more modern name is a "dental panoranic tomograph" (DPT).
7. It takes a panoramic film by having a motor driven x-ray tube and film cassette holder which encircles around the subjects face. The subject sits or stands upright, and special supports keep the head still during an exposure time of up to 15 seconds.
8. The cassette holds a special 13x31 cm film. This view shows all the teeth along with their roots and crowns in a single view.
9. As with the whole human body, the teeth show changes with age. Some changes are seen directly during inspection of the mouth, others are only seen under the microscope.
10. It has been shown that the state of teeth has a closer correlation with age than any other hard tissue of the body

Changes in the Teeth

After the eruption and calcification of the 3rd molar (max. 25yr of age), estimation of age in adults can be done based on the physiological changes of teeth.

Gustafson used the following criteria

1. Attrition- wearing down of the incisal or occlusal surface.
2. Paradentosis- loosening of teeth due to gum retraction.
3. Secondary dentine- deposition of dentine in the pulp cavity.
4. Cementum apposition- deposition of cementum in the root
5. Root resorption
6. Transparency of root- this is most reliable criteria.

He developed a ranking scale from 0-3 for each of six criteria. By studying the cross section of a tooth microscopically, points are assigned to the various changes, and the total score obtained is applied to the following regression formula-

Total score = A + B + S + C + R + T
Age (years) = 11.43 + 4.56 x total score
Standard Error = 3.63
Correlating coefficient = 0.98

The main drawback of this method was that all the values were given equal importance.

Average Stage of Attrition Method (ASA)

It is the best method for age estimation by dentition. This method is suitable for Indian population. Attrition method is a clinical method where the attrition of molar cusps is recorded. Attrition value of each cusp is taken following which the average is calculated. The scoring for attrition was done by using ASA chart. From these values separate equation for the 1st molar, the 2nd molar and for both the molars were made. Separate equations were again made for both maxillary and mandibular teeth and the age was calculated. Equations are as follows:

1. For maxillary teeth

First molar: age = 36.39 + 1.93 M1
For both 1st and 2nd molar: age = 25.99 + 2.09 M1 + 1.39 M2

2. For mandibular teeth

First molar: age = 24.58 + 3.78 M1
Second molar: age = 22.16 + 4.26 M2
For both 1st and 2nd molar: age = 20.08 + 2.46 M1 + 2.15 M2

The regression equation standard deviation in ASA technique ranges from ± 2.8 to ± 3.9 yr. When we use mandibular 2nd molar alone the SD is more but with mandibular 1st and 2nd molar both it is very less. This examination depends upon the personal habits of the population. E.g. Pan chewing.

Dentin sclerosis (root transparency) (Fig. 9, 11) is another feature of the pulpo-dentinal complex which was first described by Tomes in 1861 (Tomes 1861). This trait undergoes a progressive change with age but is also a defensive reaction to caries, attrition, and drug treatment. During a person's life dentin gradually becomes more calcified which is associated with sclerosis of the dentinal tubules and decreased fracture resistance. Root dentin sclerosis results in reduction of the diameter of dentinal tubules. The refraction index of the intratubular substance becomes the same as that of peritubular dentine. This process leads to a milk-glass like consistency of the dentin, which starts in the late adolescence at the apex of the tooth root and progresses towards the EDJ (Hillson 1996, Rösing and Kvaal 1998). Porter and colleagues examined the effect of aging on the mineral phase of dentin via high-esolution transmission electron microscopy. It was found that the mineral crystallites are smaller in transparent dentin and the tubule lumen appeared to be filled with coarse minerals made of hydroxyapatite. Notably differences in nanostructure between intra- and inter-tubular dentin in transparent teeth were observed. Although the nature of the age-related change is not yet known, the authors suggest a "dissolution-reprecipitation" mechanism for the formation of transparent dentin (Porter et al. 2005).

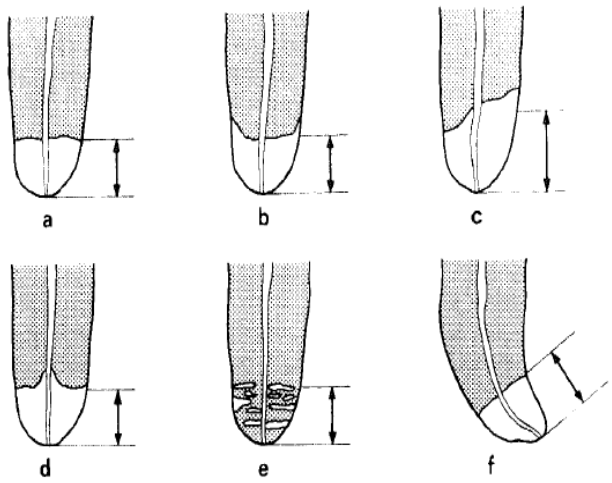


Figure 1: Types of tooth root transparency and its measurement. Reproduced from Wegener R., Albrecht H. Zur Schätzung des Alters anhand der Zahnwurzeltransparenz. Zeitschrift für Rechtsmedizin 1980;86:29-34

Figure 2: Tooth 34 of a 66 year old male, view from distal. Pronounced root transparency and periodontal regression

Root dentin transparency was first introduced in 1950 for age estimation by Gustafson as one of his proposed 6 criteria. Kamann (1998) evaluated the width of dentinal tubules via stained frozen sections. The authors found tubules with a diameter of 3-4 Km in under-aged individuals decreasing to 2 Km with advancing age. With a correlation of 0.28 Johnson (1968) failed to establish an index which increases the accuracy of age estimations based on the area of transparent dentin of tooth root sections. Bang and Ramm (1970) documented the association of age and the length of the dentin transparency and concluded that feasible results can be obtained for sectioned and unsectioned teeth specimens of up to 75 years of age. Bang and Ramm's technique was re-evaluated on a sample of histological sections derived from an osteological collection (Drusini et al. 1990). 21.13% of the cases showed <± 5 years error of

estimation, almost 27% ± 5-10 years error and more than 15% were calculated to have more than ± 20 years error of estimation. The authors concluded that it might be disadvantageous to carry out Bang and Ramm's technique on sectioned teeth because of its destructive character, and due to the fact that sections might not reflect the real limit of the transparent dentin (especially in multirooted teeth). Drusini et al. (1991) made an attempt to evaluate the extent of root dentin transparency via computerized densitometric analysis to avoid the typical problems in establishing the boundary between opaque and transparent dentin in both, histological sections and intact teeth. The results showed no superiority of the image analysis system as compared to the caliper. Difficulties in estimating chronological age of skeletal material using the extent of root dentin transparency were reported by Sengupta et al. (1999). The authors applied a protocol for the assessment of root dentine transparency to modern material and to a historic Spitalsfield's sample. The modern sample turned out to correlate well with chronological age whereas the majority of the archaeological individuals were not measurable due to post mortem changes. Another study tested root dentin transparency for age at death estimation in 33 cases from the Charité University Hospital. A correct age estimate was obtained in 18 cases, 14 cases lay within ± 10 years of the true age (Olze et al. 2004a). Mandojana and colleagues (2001) analyzed morphological age-related differences between freshly extracted teeth and teeth derived from skeletal material. Higher values of dental colour, transparency length, attrition, cementum apposition, and secondary dentin were found in skeletal material when compared to the freshly extracted specimens. These results suggest that the post mortem interval could affect age-related morphological changes and requires caution regarding age estimation.

Another technique that uses root dentin transparency for age estimation is the method after Lamendin et al. (1992). Lamendin and colleagues presented an approach for age determination for single teeth that used periodontosis height and root transparency as parameters for age prediction (Lamendin et al. 1992) (Fig. 10, 11). Lamendin's mean error was found to be between 8.4 years in the control sample and 10 years in the working sample. The use of gingival regression as a variable has been criticized because the attachment level can easily be influenced by factors such as bad dental hygiene, irritation, systemic diseases, and drug treatment (Foti et al. 2001). The Lamendin two criteria method was also applied to a skeletal collection (Prince et al. 2002) of non-French origin. It was shown that the method also worked well with this material although the statistical analysis suggested that sex may be a relevant factor when employing the Lamendin method. The authors proposed to evaluate potential sex differences concerning the variables "periodontosis" and "root transparency" in further research. González- Colmenares et al. (2007) tested the sex-specific formulas developed by Prince et al. (2002) and obtained more accurate age estimations in a Spanish population than with Lamendin's original equation (1992). It was reported that the application of the Lamendin technique can be problematic in case of historic skeletal material (Megyesi et al. 2006). The mean error was found to be higher than in the original paper; approximately 35% of the evaluated teeth did not show any root transparency. The authors concluded that the presence of root transparency and the preservation of the teeth had a significant influence on the accuracy of the age estimate. Martrille and colleagues evaluated skeletal individuals from the Terry collection and found a quite similar mean error (ME) of 11.3 years for the Lamendin method when compared to the original results. The lowest mean error and standard deviation (SD) that was found was 6.1 years and ± 4.7 years in the age group of the 41 to 60 year old individuals (Martrille et al. 2007).

Although the Lamendin method contains a certain degree of subjectivity due to the diffuse limit between transparent and opaque dentin, it offers the chance of dental age estimation in the field situation (Slaus et al. 2007).

Radiological examination of appearance of ossification centers and fusion of epiphysis:

1. All epiphyses around then elbow joint complete fusion by 16 yr.
2. All epiphyses around hip and ankle joints fuse by 17ys.
3. All epiphyses around shoulder and knee fuse by 18yr.
4. All epiphysis around the wrist fuses by 19 yr.

The skeletal development of hand and wrist represents the development of whole skeleton as "pars pro toto" and informs about the skeletal age corresponding with chronological age.

The wrist joint presents quite a number of bones for radiological analysis. This is one of the reasons why many workers regard it as the single most important joint in the estimation of age. Other advantages stem from the little irradiation required to show these bones and the ease of radiographic positioning. The clavicle begins to ossify before any other bone in the body. Two centers appears in the shaft between 5th and 6th weeks of intra uterine life, and fuse about 45th day. The secondary centers appear for sternal end around 19 yr and unite with the shaft by 21 yr. These are the usual figure accepted by Indian medico legal practitioners.

5. Conclusion

Above methods of age estimation can be tried in forensic cases in the identification of the individual with no birth records. Expertness and the combination of physical examination of the suspect, dental examination which records dental status including OPG, x-ray examination of the left hand and wrist and radiographic or CT survey of the clavicle lead to conclusions regarding the estimated age. A useful support in criminal cases to assess adolescents and young adults due to legal protection in the court. Every year the study group proves the practicability of the methods, points the way to the future and organizes lectures regarding the results in research and in practice. "Still the opinion of a doctor on age considering the above mentioned parameters is merely an opinion and not the full proof of age".

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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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Author Profile

Manoj Kumar (India): awarded Associate Professor on Feb 7th,2014 in Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University and Headship on May 6th,2014.Did his M.B.B.S from Patna Medical College Hospital, Patna in 1999.Got his MD in Forensic Medicine in 2004 from Institute of Medical Sciences, BHU. He has been actively involved in academic, research and medico-legal work. He has around thirty one research papers and two books published till now.

Dr. Sunil Kumar tripathi was born in 30th January 1948. He became professor in Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University in July 2007. He has over 35 years of teaching experience of MBBS and MD students. He had published more than 77 articles in reputed journals. He had guided 7 MD and 12 PhD theses. He had attended and presented papers in many national and international conferences. He has many academic honors, awards and membership of professional bodies. He headed the department for more than 6 years. He is expert member of many advisory/selection committee as well as involved in numerous expert panels.