**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).

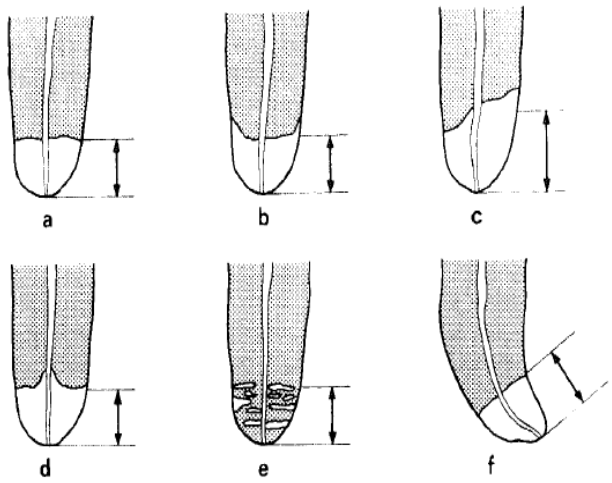


**Figure 1:** Types of tooth root transparency and its measurement. Reproduced from Wegener R., Albrecht H. Zur Schätzung des Alters anhand der Zahnwurzeltransparenz. Zeitschrift für Rechtsmedizin 1980;86:29-34

**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".

## Acknowledgement

I am grateful to my supervisor Dr. S.K. Tripathi, Professor, Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi and Co-supervisor Dr. R.C. Shukla, Professor, Department of Radio diagnosis & Imaging, Institute of Medical Sciences, Banaras Hindu University, Varanasi for his invaluable help and guidance. I owe him my sincere thanks for his encouraging attitude and inspiration given to me at various stages of this study. I am very much thankful to Dr. N.K. Jain, Arihant Diagnostics, Varanasi for providing me various OPG images used in this study.

## Conflict Of Interest

Nil

## Source of Funding

This research was not financially supported by any funding agencies.

## 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.

## References

[1] Bang G, Ramm E Acta Odontol Scand 1970; 28:3-35. Determinations of age in humans from root dentin transparency.
[2] Drusini A, Volpe A, Dovigo S Z Morphol Anthropol 1990; 78:169-174. Age determination in human adults by dental histology.
[3] Foti B, Adalian P, Signoli M, Ardagna Y, Dutour O, Leonetti G Forensic Sci Int 2001;122:101-106. Limits of the Lamendin method in age determination.
[4] González-Colmenares G, Botella-López MC, Moreno-Rueda G, Fernández-Cardenete J J Forensic Sci 2007; 52:1156-1160. Age estimation by a dental method: a comparison of Lamendin's and Prince & Ubelaker's technique.
[5] Hillson S Dental Anthropology. Camebridge: Camebridge University Press; 1996.
[6] Johnson CC Oral Surg Oral Med Oral Pathol 1968; 25:834-838. Transparent dentine in age estimation.
[7] Kamann WK DZW Spezial 1998; 10:4-7.[Article not in English] Altersveränderungen im stomatognathen System.
[8] Lamendin H, Baccino E, Humbert JF, Tavernier JC, Nossintchouk RM, Zerilli A J Forensic Sci 1992;37:1373-1379. A simple technique for age estimation in adult corpses: the two criteria dental method.
[9] Mandojana JM, Martin-de las Heras S, Valenzuela A, Valenzuela M, Luna JD J Forensic Sci 2001;46:889-92. Differences in morphological age-related dental changes depending on postmortem interval.
[10] Martrille L, Ubelaker DH, Cattaneo C, Seguret F, Tremblay M, Baccino E J Forensic Sci 2007;52:302-307. Comparison of four skeletal methods for the estimation of age at death on white and black adults.
[11] Megyesi MS, Ubelaker DH, Sauer NJ Am J Phys Anthropol 2006; 131:363-367. Test of the Lamendin aging method on two historic skeletal samples.
[12] Olze A, Geserick G, Schmeling A J Forensic Odontostomatol 2004a; 22:28-33. Age estimation of unidentified corpses by measurement of root translucency.
[13] Porter AE, Nalla RK, Minor A, Jinschek JR, Kisielowski C, Radmilovic V, et al. Biomaterials 2005;26:7650-7660. A transmission electron microscopy study of mineralization in age-induced transparent dentin.
[14] Prince DA, Ubelaker DH J Forensic Sci 2002; 47:107-116. Application of Lamendin's adult dental aging technique to a diverse skeletal sample.
[15] Rösing FW, Kvaal SI Dental Age in Adults – A Review of Estimation Methods. In: Alt KW, Rösing FW, Teschler-Nicola M (eds.) Dental Anthropology. Fundamentals, Limits, and Prospects. Wien, New York: Springer; 1998. P.443-468.
[16] Sengupta A, Whittaker DK, Shellis RP Arch Oral Biol 1999; 44:889-899. Difficulties in estimating age using root dentine translucency in human teeth of varying antiquity.
[17] Slaus M, Strinovic D, Pecina-Slaus N, Brkic N, Balicevic D, Petrovecki V, et al. Forensic Sci Int 2007;171:37-43. Identification and analysis of human remains recovered from wells from the 1991 War in Croatia.
[18] Tomes A; 1861. cited in Feiler E Z Stomat 1923;21:595-614. [Article not in English] Die Transparenz des Zahnbeines.

## 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.