JOURNAL OF FORENSIC MEDICINE SCIENCE AND LAW

Official Publication of Medicolegal Association of Maharashtra

Editor-in-chief
Dr Ravindra Deokar

Associate Editors
Dr Sadanand Bhise
Dr Sachin Patil

**MULTISPECIALITY, MULTIDISCIPLINARY, NATIONAL
PEER REVIEWED, OPEN ACCESS, MLAM (SOCIETY) JOURNAL
Indexed with Scopus (Elsevier) & Index Copernicus (Poland)**

Original Research Article

Age Estimation in Children and Adolescent in Central Indian Population: A Comparative Analysis of Demirjian's and Kronfeld's Method

Shweta Gangotri Sumbh[a*], Bharat Sumbh[b], Jagdhari Smriti[c], Ranu Ingole[d], Nupur Kokane[e]

[a]Assistant Professor, Department of Oral Medicine & Radiology; [e]Assistant Professor, Department of Public Health Dentistry, Government Dental College Nagpur, Maharashtra, India. [b]Professor & Head, Department of Dentistry, Atal Bihari Medical college and Hospital, Vidisha, M.P, India. [c]Reader, Department of Oral Medicine & Radiology, VSPM'S Dental College & Research Center, Nagpur. [d]Associate Professor, Oral Medicine & Radiology, Government Dental College & Hospital, Nagpur, Maharashtra, India.

Article Info

Abstract

Introduction: Radiology plays an indispensable role in human age determination. Developing teeth are used most reliably in age estimation in forensic science as they are the most indestructible part of the body. **Aim:** This cross-sectional study aims in comparing an age old Kronfeld's method and modified Demirjian's method of dental age estimation in reported MLC cases in Government Dental College. **Method:** The comparison was done among 120 individuals using digital Orthopantomogram. The subject comprised of male and female having age range of 7-22 years reported to GDC for age estimation. The analysis of 120 cases for age estimation was done by both Kronfeld's and Demirjian's method. The study was processed by paired T test. **Results:** Both the methods of age estimation show significant results in relation to actual age individually but comparison between the two method shows Kronfeld's method gave age estimates nearer to the actual age. **Conclusion:** Kronfeld's method can be used in analysis of age estimation cases.

1. Introduction

An indispensable role is played by radiology in human age determination. Developing teeth are used most reliably in age estimation in forensic science as they are the most indestructible part of the body.[1,2] Age estimation of children and adolescents is vital for responding to plethora of legal questions, including issues of status of majority and criminal liability. The teeth are useful predictors of age in this age group, particularly because of their relative accuracy and also because of the lack of other reliable predictors.[2,3,4] Various methods for dental age estimation are practiced worldwide. Logan and Kronfeld developed a method depending on the calcification and development of permanent and deciduous teeth giving the age estimates in humans.[3]

Schour and Masseler (1941) had studied the development of deciduous as well as permanent teeth, mentioning 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them.[3,5] The American Dental Association (ADA)

***Corresponding author:** Dr. Shweta Gangotri Sumbh, Assistant Professor, Oral Medicine & Radiology, Govt. Dental College & Hospital, Nagpur, Maharashtra, India. Email- shwetagangotri@yahoo.com (M): +91-8788211082.

has periodically updated these charts and published them in 1982 making it possible to directly compare the calcification stages of teeth on radiographs with the standards. They have their origin in work by Logan and Kronfield.[6,7,8]

Radiographically, the mineralization of deciduous incisors commences at the age of 16th week of intrauterine life. These stages of intrauterine mineralization and subsequent development, eruption and root completion were evaluated in deciduous (3-4 months intrauterine) and permanent (25 years after birth) and projected in two different charts in data provided by Kronfeld in 1935.[5]

Demirjian's developed a formula for age estimation based on OPG but this formula resulted in inferior age prediction when used in Indians (9.2% misclassification at 99% confidence interval vs. 0% misclassification in the original study); therefore, India-specific regression formulas were developed, which gave better age estimates (mean absolute error, MAE = 0.87 years) than the original formulas (MAE = 1.29 years). This suggests that Demirjian's 8-teeth method also needs adaptation before use in diverse populations.[2] Age estimation using Demirjian's formula resulted in an inferior age prediction of the Kanyakumari population, whereas there was very little difference between estimated dental age and chronological age calculated using an Indian-specific formula.[2,4,5]

On the evaluation of the above-mentioned methods of age estimation, this research has been planned to compare Demirjian and Kronfeld's age estimation method using OPG.
Also, the comparative results of Demirjian's and Kronfeld's methods of age estimation are not assessed in children and adolescents. This study aims to compare the efficiency of Demirjian and Kronfeld's age estimation method using OPG.

2. Material and methods:

The present study was designed as an analytical and observational study, conducted on patients attending the outpatient department of Oral Medicine & Radiology, Government Dental College & Hospital, Nagpur, Maharashtra state, India.

Sample

A sample size was calculated using epi info and taking into consideration previous studies. Considering the 10% attrition sample size was 120 for each group.

A convenience sample was used to recruit patients, from the patients reporting to the Outpatient department. Only those patients were included in the study who have been advised OPG from other departments and are in the age range of 7-22 years to avoid ethical issues of radiation exposure.

Patients having any pathologies like- fractures, cysts, tumors, fibrous dysplasia etc., missing teeth, congenital anomalies, systemic disease and uncooperative were excluded from the study sample.

The chronological age of the subject was noted and verified with valid official credentials (Aadhaar card, voters card etc.)

Analysis

The subjects underwent an Orthopantomogram scan (OPG) on the Sirona Orthophos XG OPG Machine. The digital OPG images obtained were saved in jpeg format keeping the exposure parameters constant for all the subjects and as per the instruction provided by the manufacturer. These OPG images were viewed in a dimly lit room on a desktop monitor. The demographic data was removed from the OPG images to blind the observers to the age and sex of the patient.

All 120 subjects were first analyzed for Kronfeld's method of age estimation. The observer used the chart provided by Kronfeld **(Figure 1 – A & B)** and the observations were recorded in Excel sheet by observer number 1 having expertise in Forensic Odontology.

These same subjects were analyzed for Demirjian's method of age estimation. The observer used the chart and scoring table provided by Acharya[2] for the Indian specific population which is a modified version of Demirjian's age estimation method **(Figure 2 & Table 1)** and the observations were recorded in Excel sheet by observer number 1 having expertise in Forensic Odontology.

The above procedure was carried out for observer number 2 who has expertise in oral radiology and observations were recorded in separate Excel sheets.

3. Results:

The present study was conducted on 120 subjects of which 16 (13.34%) were males and 104 (86.66%) were females. There was randomization in the sample collection. The majority of sample subjects were between 12-19 years of age.

The inter-observer bias was assessed by including two independent observers (observer number 1 with expertise in Forensic Odontology and observer number 2 with expertise in oral radiology) to assess the samples. Referring to a single measurement, i.e.

Figure 1 (A & B): Chart by Kronfeld- (A): Development of the deciduous teeth. Data from Kronfeld (1935), Y= age in years; M= age in months; MIU= months intrauterine; A= deciduous central incisor; E= deciduous second molar; (B): Development of the axillary and mandibular permanent teeth. Data from Kronfeld (1935) 1= First permanent incisor; 8= third permanent molar.
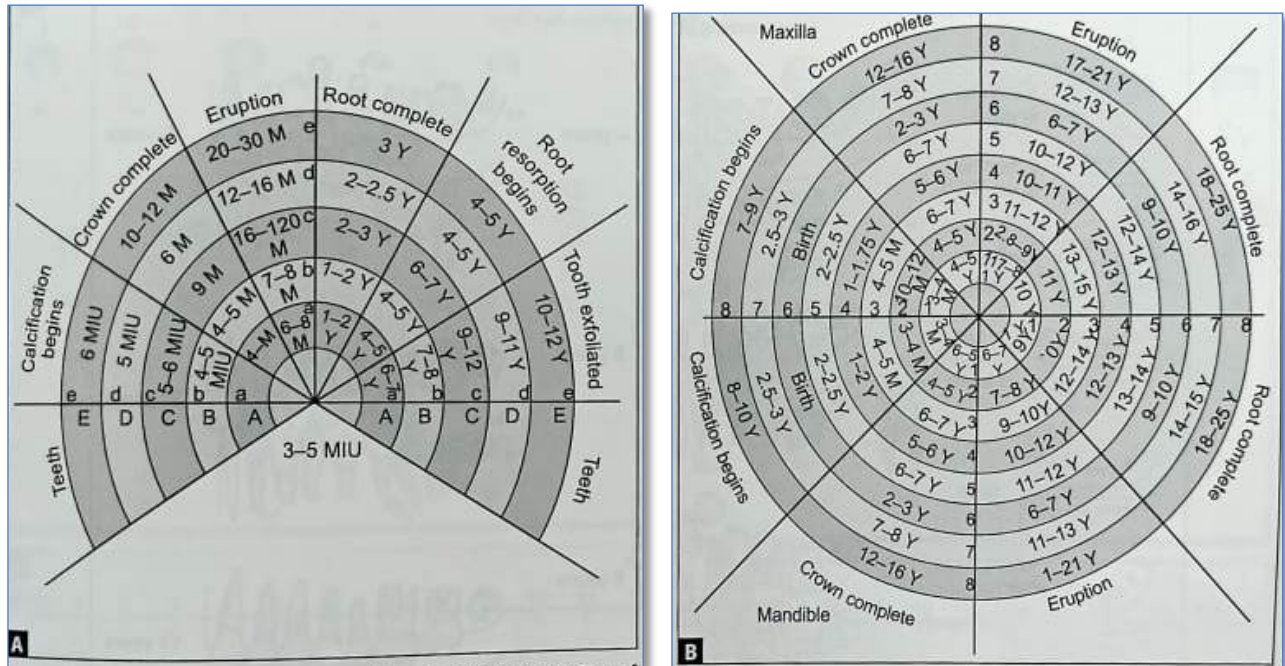
**Table: 1 (A & B) Demirjian's scoring table modified by Dr. Acharya for Indian population**

A: Maturity Scores for Females

Stage	31	32	33	34	35	36	37	38
0								6.40
1							2.57	7.74
2					2.43			8.92
3				2.56	3.43		2.65	9.31
4			2.55	3.54	3.83		4.10	10.22
5	2.58	2.65	3.15	5.09	5.75	2.58	6.51	11.04
6	3.10	4.54	5.40	6.31	6.81	3.25	8.00	12.65
7	5.02	5.40	7.19	8.09	8.70	4.25	9.13	13.77
8	6.66	7.02	9.22	9.82	10.80	6.88	11.00	14.45
9	10.61	10.89	11.99	12.29	12.79	10.94	13.84	16.65

B: Maturity Scores for Males

Stage	31	32	33	34	35	36	37	38
0							1.70	6.19
1					1.69		2.98	7.64
2				1.70	2.27		3.41	8.28
3			1.70	1.98	3.41		4.74	8.86
4			2.67	3.52	3.41		4.88	9.89
5	2.31	2.55	4.34	5.19	5.59	2.13	6.69	11.17
6	4.35	4.71	6.14	6.47	6.96	3.73	7.89	12.25
7	5.16	5.75	7.59	8.18	8.68	4.94	9.08	13.66
8	6.56	6.97	9.52	9.84	10.64	7.00	11.13	14.07
9	10.68	10.91	12.56	12.57	13.11	11.22	13.63	15.32

Figure 2: Tooth development chart
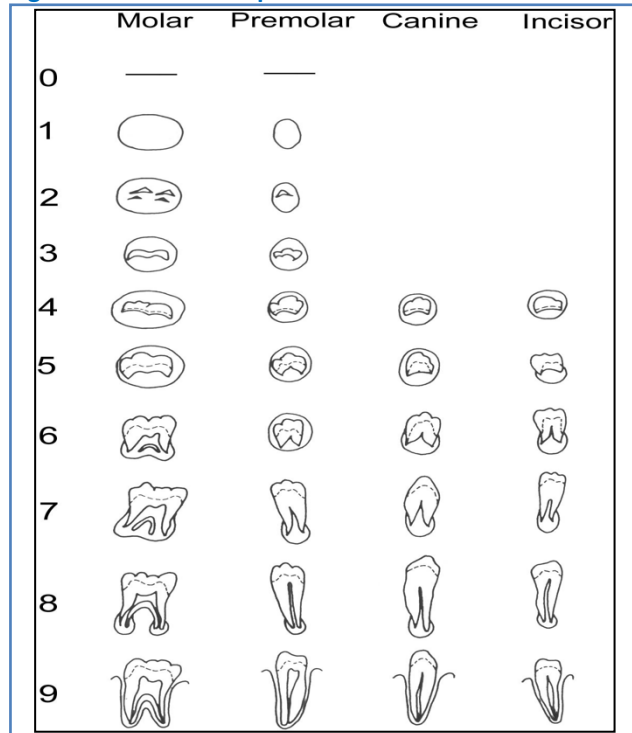
coefficient value was 0.96 {96% CI: 0.96-0.99} indicating an excellent agreement among the observers. There were two cases in which the

disagreement was observed. To assess the intra-observer bias, the same subject OPG was evaluated thrice by the first observer at a gap of one week between each evaluation.

The ICC obtained was 0.98{98% CI: 0.96-0.99}, with a p-value of < 0.0001 indicating excellent agreement between the scores obtained at three different instances. There was one case in which disagreement was observed in the time interval. For both inter and intra-observer assessment disagreement was only for one stage.

Table 2: Paired Samples Statistics (SD: Standard Deviation, Std. EM: Standard Error of Mean)

		Mean	N	SD	SEM
Pair 1	Kronfeld	16.63	120	3.234	.295
Chronological age		16.05	120	2.798	.255
Pair 2	Demirjian	16.51	120	2.929	.267
Chronological age		16.05	120	2.798	.255

Table 3: Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Kronfeld &	120	.820	.000
Chronological age				
Pair 2	Demirjian &	120	.810	.000
Chronological age				

Table 4: Paired Samples Test

		Paired Differences			
		Mean	SD	SEM	95% Confidence
					Lower
Pair 1	Kronfeld – chronological age	.578	1.855	.169	.243
Pair 2	Demirjian – chronological age	.463	1.768	.161	.143

Table 5: Paired Samples Test

		Paired			
		95% Confidence	t	df	Sig. (2-tailed)
		Upper			
Pair 1	Kronfeld – chronological age	.914	3.416	119	.001
Pair 2	Demirjian – chronological age	.782	2.867	119	.005

The high level of agreement indicates that the scoring system and chart used for analysis are reproducible and reliable.

The recorded data was analyzed using SPSS 20 statistical software. The correlation coefficient was 0.820 for Kronfeld's method and 0.810 for Demirjian's method which shows high agreement between the chronologic age and dental age **(Table,2,3 & 4)**.

Both Demirjian's and Kronfeld's methods are highly significant but Kronfeld's method showed higher

significance (0.001) compared to Demirjian's method (0.005) of age estimation **(Table 5)**.

4. Discussion:

Absolutely, age is a critical factor in both identifying individuals and addressing various legal and medical issues.[9,10] The evolution of forensic odontology is believed to have started in the Garden of Eden era and has revolutionized the present age of genetics.[11]Technological advances in dentistry and medical record-keeping have indeed increased the likelihood of using dental records for forensic

purposes.[12] Estimating age from teeth is considered a reliable method in forensic science and archaeology due to preservation of teeth for longer duration.[13]

The development and eruption of teeth are useful dental events to assess age. The tooth development process starts from the initiation of tooth bud formation from the embryonic cells and continues till complete root development.[1,7]

Schour and Massler in 1941 introduced a chart explaining the development and eruption of human dentition.[3] They studied the development of deciduous and permanent teeth in seven stages, i.e., prenatal (4.5–5 months utero), neonatal (at birth), infancy (birth to 6 months), childhood (2–6 years), early grade school (6–10 years), prepubertal period (10–12 years), and adulthood (12–21 years) using histological and radiographical method.[3] They also compared the calcification stages of teeth on radiographs with the standards. The proposed numerical chart describes 21 chronological steps of teeth development ranging from 5 months in utero to 21 years of age. The American Dental Association (ADA) has periodically updated these charts and published them in 1982.[14] This chart has its origin by Logan and Kronfeld but there is not much data available on the work done by Logan and Kronfield.[6,7,8]

In the present study, an attempt was made to utilize this simple technique to estimate the age of children and adolescents and compare it with the well-established Demirjian's modified technique of age estimation.

In 1935, Kronfeld and Logan developed the technique for age estimation in deciduous (4 MIU) till the age of 25 yrs.[1,3,4,5] This technique is very simple and utilizes OPG and a radiologist which was appreciated in our study. There was an underestimation of age in 2 subjects (1.66%) and an overestimation in 2 subjects (1.66%).

Modified Demirjian's technique with Indian specific formula developed by Dr. Acharaya gave a low error rate in estimating age which justifies its application in the East Indian population.[4,9] Age estimation using Demirjian's formula resulted in an inferior age prediction of the Kanyakumari population, whereas there was very little difference between estimated dental age and chronological age calculated using an Indian-specific formula as analysed by Akhil S et al which is by our study (P= 0.05).[4] In this study, there was an overestimation of age in 6 subjects (5%) and an underestimation in 8

subjects (6.66 %) in Demirjian's method of age estimation.

In the above age estimation methods i.e. Kronfeld and Demirjian's the common requirement was OPG- Orthopantomogram. Demirjian's method required an additional computer system for analysis using the sex-specific formula and charts provided for stage identification and score table. Comparatively, in Kronfeld's method, only a chart is required for the estimation. Besides age estimation from teeth development, there are other methods of age estimation in living and dead.[15-20]

The advantage of Demirjian's method is that it can give exact age estimates but there is a practice to consider the range, also there is a separate formula and score for male and female. On the other hand, in Kronfeld's method, there is no requirement for any formula and a separate chart is provided for the maxilla and mandible, also using this method estimation of age can be done from the age of 4 months in utero till 25 years of age which proves its applicability in a wide age range.

5. Conclusion:

In conclusion, this study compares Demirjian's and Kronfeld's methods for age estimation in Central Indian population. Kronfeld's approach, utilizing panoramic radiographs, demonstrates higher significance and practicality, making it a reliable tool for age estimations in children and adolescents. The study highlights Kronfeld's method as a preferred option, emphasizing its simplicity and potential for application in forensic contexts, contributing to the advancement of forensic odontology.

References:

1. Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofac Radiol. 2011;40(4):199-212.
2. Acharya AB. Age estimation in Indians using Demirjian's 8-teeth method. J Forensic Sci. 2011;56(1):124-7.

3. Logan W, Kronfeld D. Development of the human jaws and surrounding structures from birth to the age fifteen years. J Am Dent Assoc. 1933; 20:379–427.

4. Akhil S, Joseph TI, Girish KL, Sathyan P. Accuracy of Demirjian's and Indian-specific formulae in age estimation using eight-teeth method in Kanyakumari population. Indian J Dent Res. 2019; 30:352-7.

5. Karjodkar FR. Role of dental radiology in forensic odontology. In: Textbook of dental and maxillofacial radiology. 2nd ed. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd; 2009. p. 929–63.

6. Corral C, García F, García J, León P, Herrera A, Martínez C et al. Chronological versus dental age in subjects from 5 to 19 years: a comparative study with forensic implications. Colomb Med. 2010;41(3):215-23.

7. George GJ, Chatra L, Shenoy P, Prabhu RV. Age determination by Schour and Massler method: A forensic study. Int J Forensic Odontol. 2018;3:36-9.

8. Ebrahim E, Rao PK, Chatra L, Shenai P, Veena KM, Prabhu RV. Dental age estimation using Schour and Massler method in South Indian children. Sch J Appl Med Sci. 2014;2(5C):1669-74.

9. Dere RC, Maiyyar AR, Patil SS, Deokar RB, Kukde HG. A Two-year Prospective Study in Western Maharashtra in Relation to Ossification Centers around Wrist Joint for Age Determination using Radiological Examination in Sportspersons. Int J Educ Res Health Sci 2018;1(2):33-9.

10. Dere RC, Maiyyar AR, Patil SS, Deokar RB, Kukde HG. Age Estimation using Radiological Examination of Elbow Joint of Sportspersons in Western India. Int J Educ Res Health Sci 2017; 3 (3) :139-45.

11. Balachander N, Babu NA, Jimson S, Priyadharsini C, Masthan KM. Evolution of forensic odontology: An overview. J Pharm Bioallied Sci. 2015 ;7(Suppl 1): S176-80.

12. Karmarkar MD, Forensic Medicine and development of sub-specialities. J Forensic Med Sci Law. 2018;27(1):1-2.

13. Ramkumar J, Ganesh R, Naveen N. Age estimation from radiographic evaluation of various developmental stages of maxillary third molars and its associated gender variation. J Forensic Med Sci Law. 2022;31(2):33-7.

14. Ciapparelli L. The chronology of dental development and age assessment. In: Clark DH, editor. Practical Forensic Odontology. Oxford: Wright Butterworth-Heinemann Ltd.; 1992. p. 22-42.

15. Bhalerao VP, Chaudhari SH, Paliwal RO. Estimation of age from the rib by phase analysis - an autopsy study in population of central India. J Forensic Med Sci Law. 2022;31(1):39-47.

16. Koulapur V, Hallikeri VR, Manoranjan B. Palm Length as an Aid for Stature Estimation in South Indian Population. J Forensic Med Sci Law. 2022;31(1):24-27.

17. Tyagi S, Vaswani V, Pathak H. Epiphyseal Fusion Around the Elbow Joint in Sports Persons and General Population. J Forensic Med Sci Law. 2020;29(2):27-33.

18. James RI, Bakkannavar S, Anita S. Estimation of age from hyoid bone – is it a viable option? J Forensic Med Sci Law. 2022;31(1):33-38.

19. Parkhe S, Kadu S, Swami A, Govekar G. A Cross Sectional Study of Age Estimation from Appearance and Fusion of Acromion Process of Scapula in Shoulder Joint by Digital X-ray. J Forensic Med Sci Law. 2021;30(2):10-15.

20. Bharti R , Saxena A. Age Estimation from Morphological Changes in Sternal End of Fifth Rib. J Forensic Med Sci Law. 2021;30(2):22-26.