A comparative study of Demirjian and Chaillet-Demirjian methods to estimate the dental age in Maharashtra's population

Lina Z. Bhoyar[1], Archana L. Mahakalkar[1]*, Rashmi V. Kulkarni[2], Ashita R. Kalaskar[2], Dhiraj Naik[3]
[1]Department of Forensic Biology, Government Institute of Forensic Science, Nagpur, Maharashtra, India
[2]Department of Oral Medicine and Radiology, Government Dental College and Hospital, Nagpur, Maharashtra, India
[3]Department of Botany, Bajaj Science College, Wardha, Maharashtra, India
archanasap79@gmail.com

Abstract

As a tool for human identity and age estimation, dental evidence is critical in a range of criminal cases and badly damaged mass disaster victims. The purpose of this study was to see if there was a difference between chronological age and estimated dental age using the Demirjian and Chaillet-Demirjian methods in Maharashtra children and adolescents. Demirjian and Chaillet Demirjian techniques were used to evaluate digital orthopantomograms of 96 participants aged 6 to 18years. For male and female, the difference in mean chronological age and estimated dental age was between -0.73-1.3 years and -0.9-1 years using the Demirjian method, and between -0.57-2.13 years and -1.25-0.49 years using the Chaillet-Demirjian method. The statistical analysis software Rstudio revealed a substantial positive connection in both techniques for chronological age.In addition, one-way ANOVA test in Demirjian (F = 40.63, p< 0.05) and Chaillet-Demirjian (F=7.29, p< 0.05) methods revealed statistically significant differences. In Maharashtra population, the Demirjian method shown to be more feasible than the Chaillet-Demirjian method.

Keywords: Forensic Science, Forensic Odontology, Demirjian method, Chaillet-Demirjian method, Age estimation, Maharashtra population, Teeth.

Introduction

In crime scene investigation, "Evidence is anything that can help to prove or disprove that a crime was or was not committed, and by whom"[1]. It's rightly said by Braque that "Evidence exhausts the truth". In very mutilated cases of mass disasters, accidents, fire victims etc. also in several criminal cases, the soft tissues are altered for various reasons. But teeth are the toughest, indestructible, and insusceptible to decomposition, heat, environmental factors and among the rearmost ones to splinter after death. Therefore, they are the most ordinarily practised and reliable indicators of age determination among the varied parts of the body[2,3].

Demirjian, Tanner, and Goldstein developed the Demirjian technique of age estimation in 1973. There were seven left mandibular teeth, ranging from the central incisor to the second molar, with eight developmental stages ranging from A to H, depending on tooth mineralization, which started at the first radiographic appearance of mineralization and continued until the root apex was fully closed[4].

Demirjian developed three more variations of Demirjian methods in 1976. The first method (Dem1976) used the seven teeth from central incisor to second molar, the second method (Dem1976PM$_1$) relied on the four teeth from first premolar to second molar and third method (Dem1976IN$_2$) focused on four

teeth includes second incisor, first premolar, second premolar, and second molar[5].

In 2004, Chaillet and Demirjian modified their initial procedure, which included the third molar, to make it suitable for those aged 18 and up. Thus, the radiograph was used to evaluate the left eight mandibular teeth, and tooth development was compared to a developmental chart separated into ten developmental stages ranging from 0 to 9, each with its own maturity score for both boys and girls. The maturity score was applied to applicable sex and ethnicity equations[6].

The Demirjian approach is the most effective in terms of prediction and functionality, according to the forensic age diagnostics study group, since the stages are well detailed as per radiographs, diagrams, and written criteria[7,8].

The current study used chronological age (CA) and estimated dental age (DA) to estimate and test the accuracy of the Demirjian and Chaillet-Demirjian methods in the Maharashtra population in order to encourage their usage in investigations.

Materials and methods

Study Sample: The samples were obtained from Government Dental College and Hospital, Nagpur and private dental practitioners with the approval of the Institute of Forensic

Science, Nagpur Ethical Committee. This study did not involve any human participation. The samples were taken from the patients' existing radiographs (OPG). The test was held at the Government Dental College and Hospital Nagpur's Department of Oral Medicine and Radiology between February and March 2020. A total of 96 orthopantomograms (OPG) were chosen for the study, with 46 men and 50 girls ranging in age from 6 to 18 years.

Inclusion criteria: i. Details of subjects such as Date of Birth, Date of radiographs and Gender, etc. ii. Good quality of radiograph.

Exclusion Criteria: i. Incomplete subject record. ii. Poor quality of radiograph. iii. Any dental anomalies, pathology or treatment.

The total samples were divided into 3 groups: i. Group 1: The Sample's age range between 6-16 & having 7 left mandibular teeth were evaluated by the Demirjian method. ii. Group 2: The sample's age range between 9- 18 & having 8 left mandibular teeth were evaluated by Chaillet-Demirjian method. iii. Group 3: The sample's age range between 6-16 & having 8 left mandibular teeth were evaluated by both Demirjian and Chaillet-Demirjian method and comparison was done.

The chronological age of the subject was obtained from the hospital's archive, and the date of birth was subtracted from the date of the digital orthopantomogram. Furthermore, subjects aged 6 to 18 were divided into groups with a difference of one year between them.

The digital Orthopantomograms (OPGs) were analyzed by using IWCR Rockey 10.18 software. The radiographic samples were assessed by two examiners as per developmental stage using Demirjian method and Chaillet-Demirjian method and cross-verified by Dental Radiograph Expert. The sample was removed from examination if the dental radiograph showed distortion, defect, or anomalies, while missing teeth on one side were substituted with teeth from the opposite side on the radiograph, and the developmental stage was noted.

Demirjian method for estimating dental age: The permanent mandibular teeth were rated on an 8-stage scale from A to H for each tooth stage. The rating was determined by comparing the developmental stage of a tooth on a dental radiograph with a graphic depiction of calcification stage presented in a chart for Demirjian 7-teeth method dental age calculation. The appropriate score for male or female was assigned based on the developing stage of the tooth. By summing the scores of the left seven mandibular teeth, the overall maturity score was computed. For dental age estimation, the maturity score was shown in the table of conversion of maturity score to dental age separately for male and female[9].

Teeth on the opposite side are sometimes used to replace missing teeth from one side. When the primary molar is missing, the central incisor is commonly used to fill in for it as their age corresponds[4].

Chaillet-Demirjian method for estimating dental age: Each tooth stage of the permanent mandibular teeth was scored on a 10-stage scale from 0 to 9. The rating was determined by comparing a tooth's developmental stage on a dental radiograph to a visual depiction of calcification stage presented in a chart for dental age calculation using the Demirjian 8-teeth technique. The appropriate score for male or female was assigned based on the tooth's developing stage. By summing the scores of the left eight mandibular teeth, the overall maturity score was determined. A unique regression equation was used to determine the maturity score for male and female dental age estimation[10,11].

Statistical analysis: All the statistics were entered, arranged and calculated in Microsoft Excel (Version:2010). The analysis of data was done in three parts (Part 1: Demirjian Method, Part 2: Chaillet-Demirjian Method and Part 3: Demirjian method versus Chaillet - Demirjian method). The two methods (Demirjian method and Chaillet-Demirjian method) were compared to determine the accuracy. The chronological and dental ages of the subjects were calculated and the mean and standard deviation were obtained. An independent t-test was utilised to determine the expected dental ages. A t-score was used to obtain the p-value in Social Science Statistics Software. For all statistical studies, the significance level was fixed at $p < 0.05$. Demirjian and Chaillet - Demirjian technique evaluated the association between chronological and dental ages for girls, males, and the entire sample using the Pearson product-moment correlation. Using RStudio software, a one-way ANOVA test was performed for age group and gender-based comparisons.

Results and discussion

Out of 96 OPG radiographs, 46 (47.92 %) were males and 50 (52.08%) were females. The mean age difference, as well as the difference in mean chronological age and estimated dental age, were shown in Table-1.

The study samples aged 6-16 years showed an underestimation mean difference of 0.052 for females and an overestimation mean difference of 0.036 for males in group-I (Demirjian method), with the mean difference between chronological age and dental age (CA-DA) ranging from -0.9-0.65 for females and -0.7-1.3 for males.

The study samples aged 9-18 years showed an underestimation mean difference of 1.69 for females and an overestimation mean difference of 0.154 for males in group II (Chaillet - Demirjian method), with the mean difference between chronological age and dental age (CA-DA) ranging from -1.25-0.75 for females and -0.82-2.13 for males. In group-III (Demirjian versus Chaillet-Demirjian method), the study sample aged 9-16 years showed an underestimation mean difference of 0.093 and 0.267 in Demirjian and Chaillet-Demirjian method respectively for

females, and an overestimation mean difference of 0.044 and 0.394 in Demirjian and Chaillet-Demirjian method for males.For male and female, the difference in mean chronological age and estimated age in the Demirjian technique was between -0.73-1.3 years and -0.9-1 years, respectively, while in the Chaillet-Demirjian approach, it was between -0.57-2.13 years and -1.25-0.49 years.For females, males, and the overall sample, the Pearson product-moment correlation was used to measure the correlation between chronological and dental ages by Demirjian and Chaillet - Demirjian method. In the Demirjian method, the value of R is 0.909 for female, 0.915 for males and 0.913 for the total sample and in Chaillet-Demirjian method, the R-value is 0.916 for female, 0.917 for male and 0.918 for total samples shown in the Table-2.

As shown in Figures-1-5, both the Demirjian and Chaillet-Demirjian techniques revealed a substantial positive correlation between chronological and dental ages, with p values of 0.001 for female, male, and total samples. Table-3 illustrates the results of a one-way ANOVA test using the Demirjian and Chaillet-Demirjian techniques for age group and gender-based estimates of dental age. The age group component had a p-value of 0.001, showing that the Demirjian (F = 40.63, p< 0.05) and Chaillet-Demirjian techniques (F = 7.29, p< 0.05) approaches differed statistically in estimated dental age. The p-value for a gender-based comparison for estimated dental age by Demirjian technique (F=2.65, p<0.05) was 0.106, suggesting statistically not significant difference, however the p-value for Chaillet - Demirjian approach (F = 12.63, p<0.05) was 0.001.

Table-1: Mean age difference and mean difference between chronological age and estimated dental age by methods.

| Methods	Age group	Sample size		Mean Difference		Mean (CA - DA)	
		F	M	F	M	F	M
1.Demirjian method	6-16	40	35	- 0.052	+0.036	-0.9-0.65	-07-1.3
2. Chaillet - Demirjian method	9-18	39	37	- 1.69	+0.154	-1.25-0.75	-0.82-2.13
3. Demirjian Versus Chaillet -Demirjian method	9-16	27	32	-0.093 (Demirjian) + 0.267 (Chaillet-Demirjian)	-0.044 (Demirjian) + 0.394 (Chaillet-Demirjian)	-0.9-1 (Demirjian) -1.25-0.49 (Chaillet - Demirjian)	-0.7-1.3 (Demirjian) -0.57-2.13 (Chaillet-Demirjian)

CA: Chronological age, DA: Dental age, F: Female, M: Male.

Table-2: Correlation between chronological and dental ages by methods.

| Method	r/p values	Females	Males	Total sample
Demirjian	r value	0.909	0.915	0.913
	p value	<0.001	<0.001	<0.001
Chaillet-Demirjian	r value	0.916	0.917	0.918
	p value	<0.001	<0.001	<0.001

Table-3: Age group and gender-based comparison of the estimated DA between the Demirjian and Chaillet-Demirjian methods.

| Factor	Response variables	Sum of squares	df	Mean Square	F-value	p value
Age group	Estimated DA_Dem	305.4	6	50.9	40.63	0.001*
Age group	Estimated DA_Chai	7448	6	1241.4	7.29	0.001*
Gender	Estimated DA_Dem	9.5	1	9.48	2.65	0.106[ns]
Gender	Estimated DA_Chai	2558	1	2557.7	12.63	0.001*

One-way ANOVA test *Statistically significance difference, p < 0.05. ns, Statistically not significant. Estimated DA_Dem: Estimated DA using Demirjian method, Estimated DA_Chai: Estimated DA using Chaillet-Demirjian method.
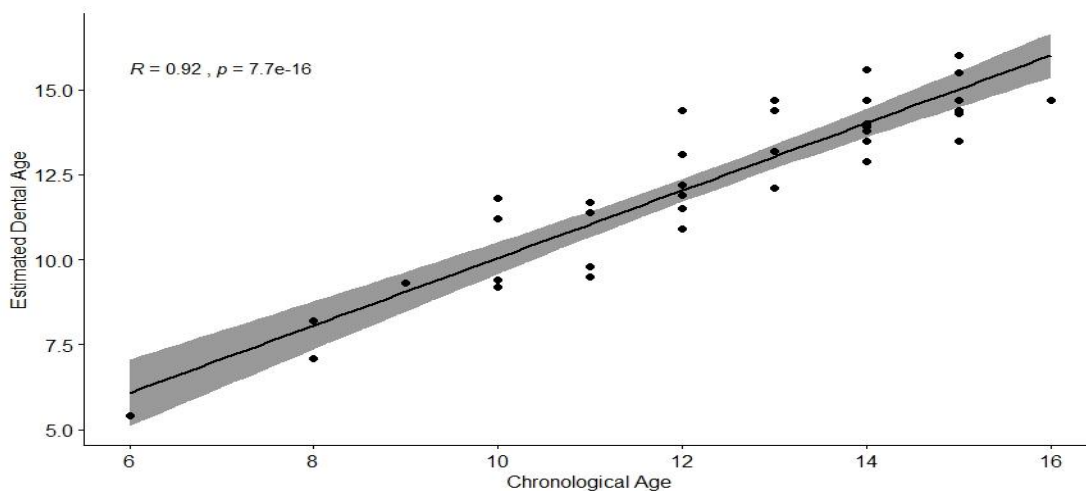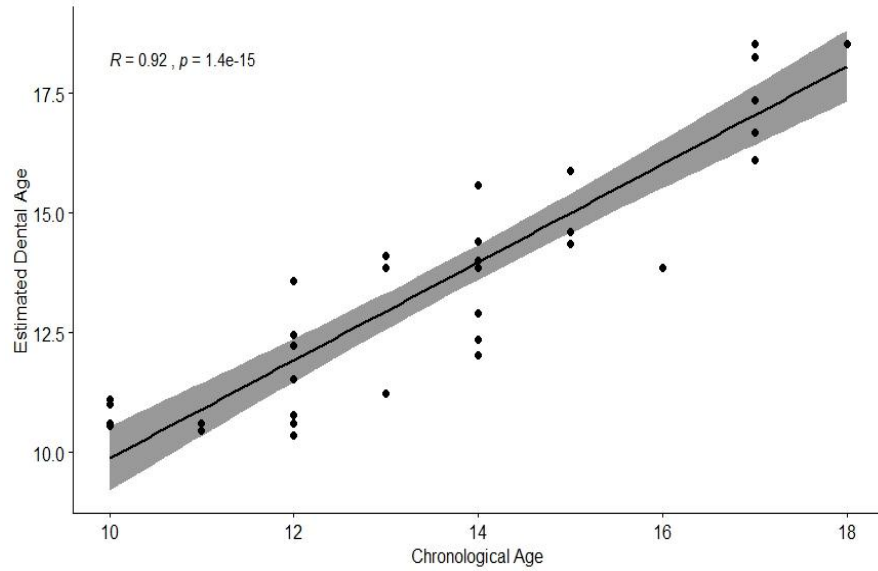
Figure-1: Showing correlation between CA and DA in males using Demirjian method.
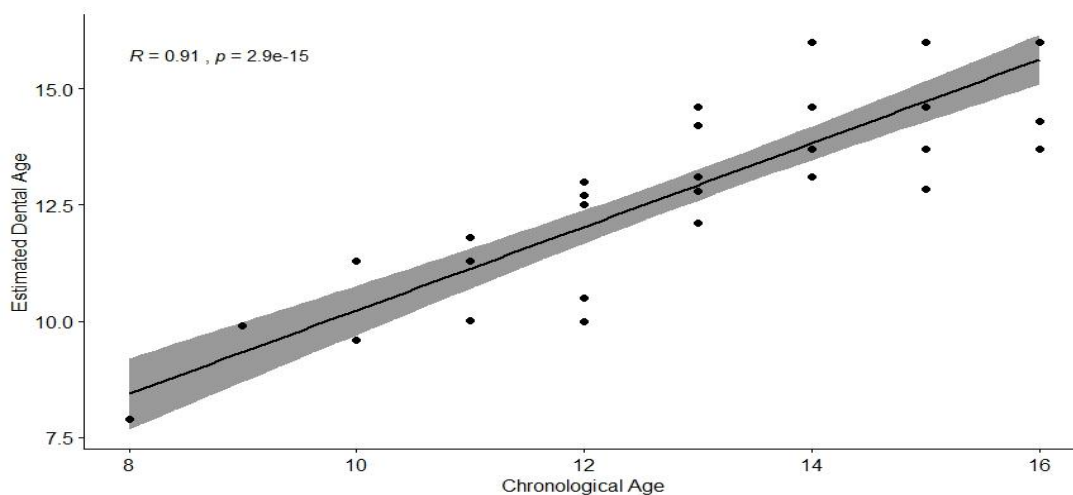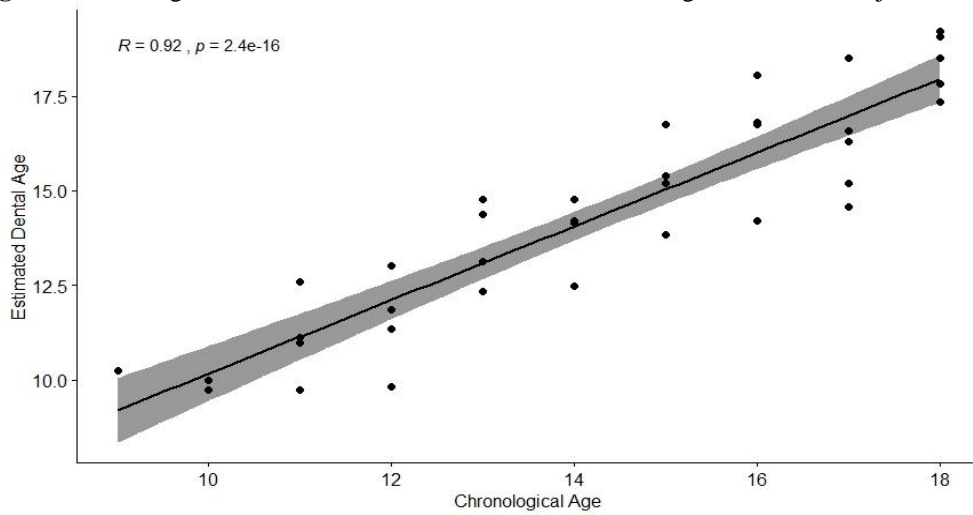

Figure-2: Showing correlation between CA and DA in females using Demirjian method.
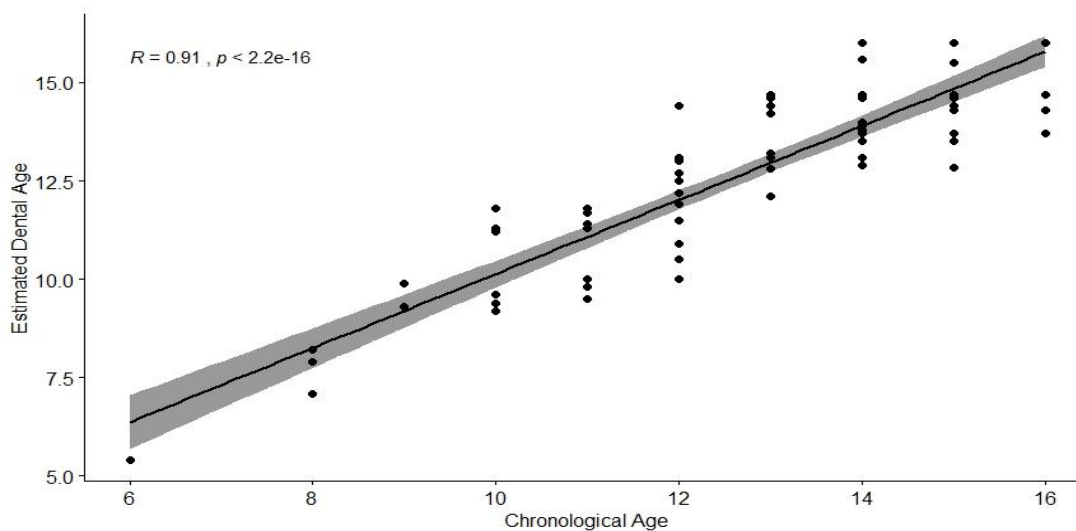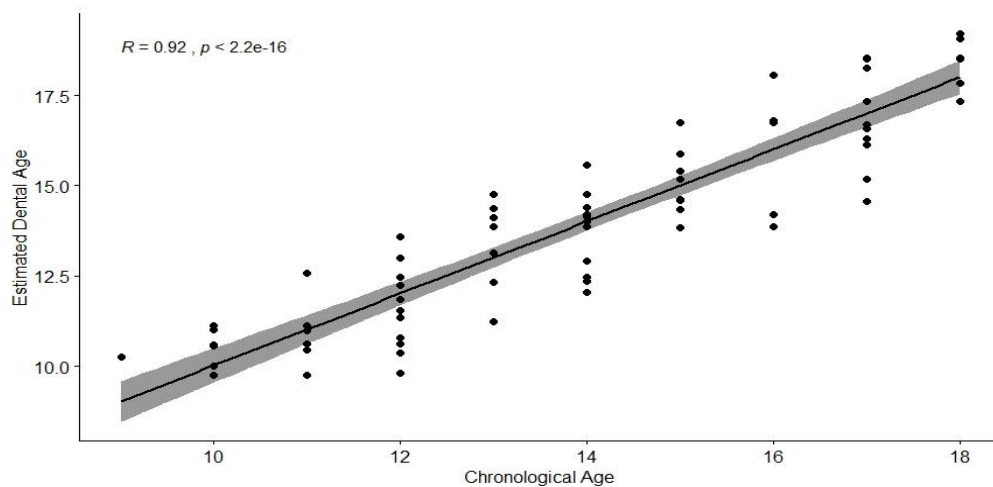

Figure-3: Showing correlation between CA and DA in whole sample using Demirjian method.

Figure-4: Showing correlation between CA and DA in males using Chaillet - Demirjian method.

Figure-5: Showing correlation between CA and DA in females using Chaillet - Demirjian method.

Figure-6: Showing correlation between CA and DA in the whole sample using the Chaillet-Demirjian method.

Discussion: Demirjian et al. utilised it to estimate dental age in French-Canadians, and it is one of the most well-established approaches for predicting age and dental maturation.While it is a simple and practical method, its accuracy for the other populations, except for the original reference population, has been questioned. Although a few individuals of similar chronological age show similar levels of dental growth, there may be differences in tooth development among individuals and population groups. Nutrition, socioeconomic position, and dietary habits, all of which differ amongst people, may be the most likely reason for variation[17].

In 2018, Singhet al. carried out a pilot study in the Haryana population, estimated the dental age using a comprehensive chart by Demirjian method, to establish a correlation between CAs and DAs which showed the underestimation of DA by 5.1 months (153 days) and 7.9 months (237 days) in male and female respectively[18].

According to Dehankar et al. (2018), accuracy is higher in the 16-18 year old age group than in the younger age groups, which is likely attributable to the third molar's good growth by this age. According to the report, the respondents' aggregate mean absolute error was 0.9111.65.[10]

In 2018, Priyanka et al. investigated the applicability of the modified Demirjian method (Chaillet-Demirjian method) in children and adolescents from the Hyderabad population, finding that the overall mean difference in CA and DA was +1.14 and +0.86 for female and male, respectively, and that DA overestimated the CA by +1.04 years in the overall sample, implying the need for population-specific formulae for each area[19].

S Akhil et al. (2019) observed that while estimating chronological age and estimated dental age using an Indian specific formula, the mean absolute error was less than when using Demirjian's formula in the Kanyakumari population[20].

In a study of Spanish and Venezuelan children, Cruz-Landeira et al. (2009) discovered that, despite the fact that dental and chronological age demonstrated a strong link, the results were contradictory. Demirjian's technique overestimates the age in the Spanish Caucasian sample when both scores are used, with the mean overestimation being greater when Demirjian's scores are used than when Chaillet's scale is used. In the Venezuelan Amerindian sample, however, Demirjian's method underestimates the age when both scores are used, with the underestimation being bigger when Chaillet's scale is used than when Demirjian's scale is used[21,22].

A comparable study in Korean juveniles and adolescents found that utilising Demirjian and modified Demirjian techniques, the CA and DA differences were -0.002 and 0.37 for men and -0.11 and 0.31 for females, respectively[23].

Another study evaluated the applicability of the Demirjian and Chaillet approaches in children from Zulia, Venezuela, and found that the Demirjian method overestimated dental age while the Chaillet method underestimated it. Both techniques underestimated age in the total samples (Demirjian = 0.201.466; Chaillet = 0.34.39)[24].

In the present study group-I (Demirjian method), the study samples aged between 6-16 years showed an underestimation mean difference by 0.052 for females and an overestimation mean difference by 0.036 for male.
In group II (Chaillet-Demirjian method), the study samples aged between 9-18 years showed an underestimation mean difference of 1.69 for female and an overestimation mean difference of 0.154 for male.

In group-III (Demirjian versus Chaillet-Demirjian method), the study samples aged between 9-16 year, showed an underestimation mean difference of 0.093 & 0.267 for female in Demirjian and Chaillet-Demirjian method respectively; whereas overestimation means difference by 0.044 & 0.394 for male in Demirjian and Chaillet-Demirjian method respectively.

The Pearson product-moment correlation (R) was determined using both Demirjian and Chaillet-Demirjian techniques for females, males, and the full sample. In the Demirjian method, R was 0.909 for females, 0.915 for males, and 0.913 for the total sample, and in the Chaillet-Demirjian method, R was 0.916 for females, 0.917 for males, and 0.918 for total samples. With p-values of 0.001 for females, males, and the entire research, both techniques demonstrated a high positive connection between chronological and dental ages.

The Demirjian and Chaillet-Demirjian methods were compared using a one-way ANOVA test for age group and gender-based estimates of dental age. The age group factor had a p-value of 0.001, showing that the Demirjian ($F = 40.63$, $p<0.05$) and Chaillet-Demirjian techniques ($F=7.29$, $p<0.05$) methods differed statistically for predicted dental age. In a gender-based comparison of estimated dental age, there was no statistically significant difference by Demirjian method as p-value was 0.106 ($F=2.67$, $p<0.05$). On the contrary, there was a statistically significant difference by Chaillet-Demirjian method as p-value was 0.001 ($F = 12.63$, $p<0.05$).

The applicability for estimating dental age using Demirjian method was only up to 16 years while for Chaillet-Demirjian method was up to 18 years. From a forensic viewpoint, the lack of an individual's antemortem record for age determination can limit the method's use in an investigation. In addition, the study likewise proposes the need for a bigger sample size to enhance the results.

Conclusion

The study concluded that the mean difference between estimated dental age (DA) and chronological age (CA) in the

Demirjian approach indicates a modest difference, however the Chaillet - Demirjian's method showed advanced mean age difference and underestimate. As a result, the Demirjian approach proved a better fit for determining dental age in Maharashtra's population.

Acknowledgement

References

1. Dutelle, A. W. (2020). An Introduction to Crime Scene Investigation. Jones & Bartlett Learning.

2. Kedarisetty, S. G., Rao, G. V., Rayapudi, N., & Korlepara, R. (2015). Evaluation of Skeletal and Dental Age Using Third Molar Calcification, Condylar Height and Length of the Mandibular Body. *Journal of forensic dental sciences*, 7(2), 121-125.DOI-10.4103/0975-1475.155077.

3. Priyadarshini, C., Puranik, M. P., & Uma, S. R. (2015). Dental Age Estimation Methods- A Review. LAP *Lambert Academic Publ.*

4. Ambarkova, V., Galić, I., Vodanović, M., Biočina-Lukenda, D., & Brkić, H. (2014). Dental age estimation using Demirjian and Willems methods: cross sectional study on children from the Former Yugoslav Republic of Macedonia. *Forensic science international*, 234, 187-e1. DOI-10.1016/j.forsciint.2013.10.024.

5. Kapoor, P., & Jain, V. (2018). Comprehensive chart for dental age estimation (DAEcc8) based on Demirjian 8-teeth method: Simplified for operator ease. *Journal of forensic and legal medicine*, 59, 45-49.DOI-10.1016/j.jflm.2018.07.014.

6. Różyło-Kalinowska, I., Kiworkowa-Rączkowska, E., & Kalinowski, P. (2008). Dental age in central Poland. *Forensic science international*, 174(2-3), 207-216. DOI-10.1016/j.forsciint.2007.04.219.

7. Odzhakov F and Apostolov A (2018). Dental age estimation – Literature review. *J Transl Sci* 5: DOI: 10.15761/JTS.1000308

8. Demirjian, A., Goldstein, H., & Tanner, J. M. (1973). A new system of dental age assessment. *Human biology*, 211-227.

9. Bijjaragi, S. C., Sangle, V. A., Saraswathi, F. K., Patil, V. S., Rani, S. A., & Bapure, S. K. (2015). Age estimation by modified Demirjian's method (2004) and its applicability in Tibetan young adults: A digital panoramic study. *Journal of oral and maxillofacial pathology:JOMFP*, 19(1), 100. DOI-10.4103/0973-029x.157223.

10. Dehankar, N., Naidu, G., Makkad, R., Nagi, R., Jain, S., & Deshmukh, U. (2018). Validity of Demirjian 8-teeth method for age estimation by orthopantomogram-A prospective study. *Journal of Indian Academy of Oral Medicine and Radiology*, 30(2), 148-148. DOI-10.4103/jiaomr.jiaomr_42_18.

11. Mincer, H. H., Harris, E. F., & Berryman, H. E. (1993). The ABFO study of third molar development and its use as an estimator of chronological age. *Journal of Forensic Science*, 38(2), 379-390. DOI-10.1520/JFS13418J.

12. Garamendi, P., Landa, M. I., Ballesteros, J., & Solano, M. A. (2005). Reliability of the methods applied to assess age minority in living subjects around 18 years old: a survey on a Moroccan origin population. *Forensic science international,* 154(1), 3-12. DOI-10.1016/j.forsciint.2004.08.018.

13. El-Bakary, A. A., Hammad, S. M., & Mohammed, F. (2010). Dental age estimation in Egyptian children, comparison between two methods. *Journal of forensic and legal medicine*, 17(7), 363-367. DOI-10.1016/j.jflm.2010.05.008.

14. Djurić, M. P. (2004). Anthropological data in individualization of skeletal remains from a forensic context in Kosovo—a case history. *Journal of Forensic Science*, 49(3), JFS2003168-5. DOI-10.1520/JFS2003168.

15. Chaillet, N., Nyström, M., & Demirjian, A. (2005). Comparison of dental maturity in children of different ethnic origins: international maturity curves for clinicians. *Journal of Forensic Science,* 50(5), JFS2005020-11.DOI-10.1520/JFS2005020.

16. Wong, H. M., Wen, Y. F., Jayaraman, J., Li, J., Sun, L., King, N. M., & Roberts, G. J. (2016). Northern Chinese dental ages estimated from southern Chinese reference datasets closely correlate with chronological age. *Heliyon*, 2(12). DOI-10.1016/j.heliyon.2016.e00216.

17. Koshy, S., & Tandon, S. (1998). Dental age assessment: the applicability of Demirjian's method in south Indian children. *Forensic science international*, 94(1-2), 73-85. DOI-10.1016/s0379-0738(98)00034-6.

18. Singh, C., Singal, K., & Kapoor, P. (2018). Age estimation using comprehensive chart for dental age estimation in Haryana population: A pilot study. *Journal of Indian Academy of Oral Medicine and Radiology*, 30(3), 281. DOI-10.4103/jiaomr.jiaomr_112_18.

19. Priyanka, M., Kiran, G., Poornima, R., Shravani, R., Shobhita, K. C., & Preethi, P. (2018). Age Estimation by Modified Demirjian's Method in Children and Adolescents of Hyderabad Population—A Panoramic Study. *Journal of Orofacial Sciences*, 10(2), 63. DOI-10.4103/jofs.jofs_61_18.

20. Akhil, S., Joseph, T. I., Girish, K. L. & Sathyan, P. (2019). Accuracy of Demirjian's and Indian-specific Formulae in

Age Estimation Using Eight-Teeth Method in Kanyakumari Population. *Indian journal of dental research: official publication of Indian Society for Dental Research*, 30(3), 352-357.

21. Lee, S. S., Kim, D., Lee, S., Lee, U. Y., Seo, J. S., Ahn, Y. W., & Han, S. H. (2011). Validity of Demirjian's and modified Demirjian's methods in age estimation for Korean juveniles and adolescents. *Forensic science international*, 211(1-3), 41-46. DOI-10.1016/j.forsciint.2011.04.011.

22. Cruz-Landeira, A., Linares-Argote, J., Martínez-Rodríguez, M., Rodríguez-Calvo, M. S., Otero, X. L., & Concheiro, L. (2010). Dental age estimation in Spanish and Venezuelan children. Comparison of Demirjian and Chaillet's scores. *International journal of legal medicine,* 124(2), 105-112. DOI-10.1007/s00414-009-0380-5.

23. Gungor, O. E., Kale, B., Celikoglu, M., Gungor, A. Y., & Sari, Z. (2015). Validity of the Demirjian method for dental age estimation for Southern Turkish children. *Nigerian Journal of clinical practice*, 18(5), 616-619. DOI-10.4103/1119-3077.154216.

24. Aissaoui, A., Salem, N. H., Mougou, M., Maatouk, F., & Chadly, A. (2016). Dental age assessment among Tunisian children using the Demirjian method. *Journal of forensic dental sciences*, 8(1), 47. DOI-10.4103/0975-1475.176956.