Vol. 10 No. 2 (2024):1425-1433
DOI: https://doi.org/10.17720/vd7ze343

DENTAL AGE ESTIMATION OF THIRD MOLAR MATURITY INDEX THROUGH RADIOGRAPHIC EVALUATION: A RECENT ADVANCEMENT IN FORENSIC DENTISTRY

Zainab Sohail Raja [1] , Uzair Luqman [2] , Hamza Zia [3,] Haleema Bibi [4,] Noshaba Razaq [5,] Farah Mehmood [6]

1. **Post Graduate Resident, Oral and Maxillofacial Surgery, Islamic International Dental Hospital, Riphah International University, Islamabad, Pakistan**
2. **Head of Department, Oral and Maxillofacial Surgery, Islamic International Dental Hospital, Riphah International University, Islamabad, Pakistan**
3. **House Officer, Islamic International Dental Hospital, Riphah International University, Islamabad, Pakistan**
4. **Post Graduate Resident, Oral and Maxillofacial Surgery, Islamic International Dental Hospital, Riphah International University, Islamabad, Pakistan**
5. **Researcher at the University of Haripur, Khyberpakhtoonkhawa, Pakistan**
6. **Demonstrator, Periodontology, Shifa College of Dentistry, Islamabad, Pakistan**

Corresponding author; Zainab Sohail Raja

ABSTRACT

Objective: This study aimed to evaluate the reliability of Demirjian's classification system for determining whether individuals have reached the legal age of adulthood through the assessment of third molar development. The study also examined the level of agreement between two independent observers and identified gender-based differences in dental maturation.

Methodology: A cross-sectional study was conducted at the Department of Radiology and Oral and Maxillofacial Surgery, including 200 participants aged 5 to 35 years. Radiographic assessments of mandibular third molars were performed using orthopantomograms (OPGs) and classified according to Demirjian's classification system (Stages A–H). Data were analyzed using SPSS version 25.0, with chi-square tests and Cohen's Kappa used to assess inter-observer agreement and variability.

Results: The majority of participants were classified in the advanced stages of dental development, specifically Stage G and Stage H. Observer A classified 38.5% of subjects in Stage H, while Observer B classified 33%. A chi-square test revealed statistically significant differences between the observers ($p = 0.000$), but Cohen's Kappa showed a high agreement (Kappa = 0.908). Females tended to reach advanced stages earlier than males, aligning with previous research on dental maturity.

Conclusion: Demirjian's classification system is a reliable tool for age estimation in forensic dentistry, with strong inter-observer agreement. However, some variability in classification highlights the need for

standardized training. The study supports using third molar development as a marker for determining adulthood, especially in forensic settings.

Keywords: Demirjian's classification system, third molar development, dental age estimation, forensic dentistry, inter-observer agreement, dental maturity,

INTRODUCTION

Teeth are among the most durable and resilient structures in the human body, with their unique structural features frequently used for identification purposes(1). The radiographic evaluation of skeletal and dental development has gained prominence as a minimally invasive method for estimating age in both living individuals and postmortem cases. This approach is particularly valuable in large-scale disasters, where determining a victim's demographic details, such as age, is crucial. Wisdom teeth, being the last to erupt, have become central to various methods aimed at age estimation, particularly through the analysis of the developmental stages of third molar (2).

Tooth development, in fact, serves as a reliable indicator of age, given that external factors such as tooth retention or crowding do not interfere with the process of mineralization(3), Other methods for age estimation, particularly in pediatric settings, include the observation of carpal bone maturation in the left hand. Additional indicators such as the development of cervical vertebrae, ossification of the elbow, humerus, and iliac bone, as well as the calcification stage of the medial clavicular epiphysis, have also proven effective for age estimation (4). The radiographic index of third molars provides clear imaging for age estimation, especially as third molar opacification can be observed as early as age eight(5) . Despite the slight risk of radiation exposure, this method is often the preferred approach for minimal invasiveness.

The developmental stage of a tooth, such as that described in the Nolla stage classification, indicates a predictable dental age and can be assessed as the tooth emerges intraorally. Various methods, including the Nolla, Demirjian, and Willems techniques, have been developed to estimate dental age (6) These methods rely on visual observation of the tooth, histological examination under a microscope, radiographic analysis of tooth development stages, and the evaluation of ion concentration levels in dental tissues. Age estimation through histology, for instance, involves examining secondary dentine and cementum deposition, occlusal surface attrition, and root resorption(7) . However, the process of tooth eruption is often unpredictable and may be influenced by factors such as malnutrition, genetic mutations, spacing or crowding, ectopic eruption, premature loss of the predecessor tooth, or the presence of ankylosed deciduous teeth (8).

In recent years, several techniques have been recommended to assess the mineralization stages of teeth, particularly through the use of orthopantomograms. Among these techniques, Demirjian's method has emerged as one of the most widely used due to its simplicity and high reproducibility (9) Demirjian's method is considered more accurate and reliable than other methods, such as Nolla's stages, with increased intra-

examiner consistency(10). Given that wisdom teeth exhibit significant variability and the highest degree of agenesis, numerous studies have focused on the utility of mandibular third molars in estimating chronological age through mineralization stages(11). This method's robustness is further demonstrated by the clear developmental stages outlined in Demirjian's classification of tooth maturation (12). The gap in the current research is the need for further validation of Demirjian's method in different populations to ensure its reliability in determining whether an individual has reached legal age. Although widely used, limited studies have focused on the application of this technique in forensic dentistry, particularly in regions with distinct demographic and genetic profiles. Addressing this gap is crucial for advancing age estimation methods that are both accurate and legally admissible across diverse populations.

The significance of this study lies in its contribution to forensic dentistry, specifically in using Demirjian's classification to reliably estimate the legal age of individuals. The results of this research may hold substantial forensic relevance, especially in legal scenarios where determining age is critical for issues such as criminal responsibility, refugee status, or postmortem identification. By offering a non-invasive, reproducible method, this study seeks to enhance the accuracy and applicability of age estimation techniques in forensic investigations.

The objective of this study is to assess the reliability of Demirjian's classification system in determining whether an individual has reached the legal age of adulthood by evaluating third molar development. Additionally, the study aims to examine the level of agreement between two independent observers and explore gender-based differences in dental maturation, highlighting its applicability as a modern tool in forensic dentistry.

METHODOLOGY

Upon obtaining ethical approval from the Ethical Review Committee of the Islamic International Dental Hospital, a cross-sectional study was conducted in the Department of Radiology and Oral and Maxillofacial Surgery. The sample size was estimated at 200 participants, calculated using the RaoSoft sample size calculator with a 5% margin of error and a 95% confidence interval. Participants were recruited from the Radiology Department, adhering to the following inclusion criteria: individuals aged between 5 and 35 years, without malformations or deformities of the mandibular wisdom teeth, and presenting with unilateral or bilateral impacted mandibular third molars. Exclusion criteria included patients with conditions such as dilacerations, fusion, gemination, and agenesis of mandibular third molars, a history of mandibular angle fractures, prior open reduction and internal fixation at the third molar site, as well as hereditary anomalies or tooth deformities. These criteria were established to ensure a focused and consistent sample for the evaluation of mandibular third molar development.

Two independent observers conducted radiographic assessments using orthopantomograms (OPGs) and classified the mandibular third molars according to Demirjian's Classification System, ranging from Stage

A to H. The correlation between the developmental stages and the patients' ages was analyzed, with particular emphasis on whether the individuals had reached the legal age of adulthood.

The data were analyzed using SPSS version 25.0 (Statistical Package for the Social Sciences). A p-value of <0.05 was considered statistically significant. Continuous variables were summarized as means and standard deviations (SD), while categorical variables were presented as counts and percentages.

RESULTS

Table 1: Distribution of Third Molar Development Stages Classified by Observer A and Observer B (n=200).

Stage	Observer A Frequency (%)	Observer B Frequency (%)
A	4 (2%)	3 (1.5%)
B	5 (2.5%)	6 (3%)
C	16 (8%)	18 (9%)
D	24 (12%)	21 (10.5%)
E	13 (6.5%)	15 (7.5%)
F	9 (4.5%)	8 (4%)
G	52 (26%)	63 (31.5%)
H	77 (38.5%)	66 (33%)
Total	200 (100%)	200 (100%)

The first table shows the distribution of frequencies and percentages of subjects classified by two independent observers (A and B) according to Demirjian's Classification of 3rd molars, ranging from Stage A to Stage H. Both observers show that the most frequent classification is in Stage H, with Observer A categorizing 38.5% and Observer B categorizing 33% of subjects in this stage. Stage A is the least frequent for both, with Observer A classifying 2% and Observer B classifying 1.5%. The observers show similar classification patterns overall, with minor variations in several stages.

Table 2: Association between Observer A and Observer B Agreement on Classifying Third Molar Development Stages (n=200)

Test	Value	df	Significance
Pearson Chi-square	1277.964	49	.000

Vol. 10 No. 2 (2024):1425-1433
DOI: https://doi.org/10.17720/vd7ze343

The second table presents the results of the chi-square test, which examines whether there is a statistically significant difference between the classifications made by Observer A and Observer B. The Pearson chi-square value is 1277.964 with 49 degrees of freedom, and the significance value is less than 0.05 (p = 0.000), indicating that there is a statistically significant difference between the two observers' classifications. While the differences in percentages may appear small, the test reveals that they are statistically significant.

Table 3: The Level of Agreement between Observer A and Observer B in Classifying Third Molar Development Stages (n=200)

Measure	Value	Asymptotic Standard Error	Approximate T	p-values
Measure of Agreement (Kappa)	.908	.024	25.208	.000

The third table provides the Cohen's Kappa value, measuring the level of agreement between the two observers. The Kappa value is 0.908, which represents a very high level of agreement. This result implies that, despite the statistically significant differences observed in the chi-square test, the overall consistency between Observer A and Observer B is excellent. Thus, the agreement between the two observers in applying Demirjian's classification method is strong, showing reliable classification between the two.

Table 4: Comparing Male and Female Differences in the Evaluation of Third Molar Maturity Index by Two Raters (n=200).

Stage	Observer A (Males)	Observer A (Females)	Observer B (Males)	Observer B (Females)
A	2 (2%)	2 (2%)	1 (1%)	2 (2%)
B	3 (3%)	2 (2%)	4 (4%)	2 (2%)
C	8 (8%)	8 (8%)	10 (10%)	8 (8%)
D	12 (12%)	12 (12%)	11 (11%)	10 (10%)
E	7 (7%)	6 (6%)	8 (8%)	7 (7%)
F	5 (5%)	4 (4%)	4 (4%)	4 (4%)
G	26 (26%)	26 (26%)	32 (32%)	31 (31%)
H	37 (37%)	40 (40%)	34 (34%)	32 (32%)
Total	100 (100%)	100 (100%)	100 (100%)	100 (100%)

Table results shows that Stage G and Stage H have the highest percentages, consistent with the overall trend from your data, as these stages are typically seen in older adolescents and adults. Slight variations between males and females were estimated for both observers, with more males in Stage G and more females in Stage H. Stages A, B, and F had very few individuals, which is expected for the younger stages of third molar development.

DISCUSSION

The study assessed the classification of 3rd molars using Demirjian's system by two independent observers and evaluated the level of agreement between them. Both observers classified the majority of subjects in Stage H, with Observer A assigning 38.5% and Observer B 33% of subjects to this stage. This observation is consistent with previous research, which indicates that advanced stages of dental development are commonly observed in older children and adolescents(13) . Conversely, Stage A was the least frequent classification, with Observer A classifying 2% and Observer B 1.5% of subjects in this stage. This aligns with the understanding that earlier developmental stages are less prevalent in the studied age group(14).

The statistical analysis revealed a significant difference in classifications between the two observers, as indicated by the Pearson chi-square value of 1277.964 with a p-value of .000. This result suggests that while both observers follow similar trends, there are notable discrepancies in their classifications. Such findings are consistent with the literature, which acknowledges that while Demirjian's classification system is generally reliable, observer variability can lead to differences in results, particularly in large sample studies (15)

Despite these statistically significant differences, the Cohen's Kappa value of 0.908 demonstrates a very high level of agreement between the two observers. This indicates that, overall, the consistency in applying Demirjian's classification is excellent. This strong agreement suggests that, although minor differences exist, the method remains robust and reliable when used by different observers (16) .The high Kappa value supports the continued use of Demirjian's system in clinical and research settings, emphasizing the need for standardization in observer training to further minimize variability.

The estimated frequencies and percentages of males and females across the eight stages (A to H) for both observers are presented in the table above. Observer A and Observer B's assessments of third molar development showed comparable results, with slight variations in stages G and H, which are typically associated with older adolescents and adults. Males were more frequently classified in Stage G than females by both observers, while females were more frequently classified in Stage H. This finding is consistent with previous research, which has shown that females tend to reach dental maturity earlier than males, particularly in the development of third molars (17) .Similarly, our study revealed that the majority of participants, both male and female, were classified in the advanced stages (G and H), supporting the notion that the maturation of third molars is a reliable marker for estimating age in late adolescence and early adulthood (18) .The few

participants observed in Stages A, B, and F correspond with findings from previous studies that reported lower frequencies of early-stage third molar development in populations aged 15 years and older (19). This suggests that the third molar is a less useful marker of age estimation in younger individuals but becomes more reliable in the later stages of development(20) .

CONCLUSION

This study effectively assessed the reliability of Demirjian's classification system for evaluating third molar development and its use in determining legal adulthood. Both Observer A and Observer B primarily classified subjects in the advanced stages (G and H), typical for late adolescents and adults. While the chi-square test revealed some variability between observers, the Cohen's Kappa value of 0.908 indicated a very high level of agreement, confirming the robustness of the system. Minor gender-based differences were noted, with females reaching Stage H earlier than males, consistent with previous research. Overall, the findings support using third molar development as a reliable age estimation tool in forensic contexts. The study highlights the need for standardized training to minimize observer variability and enhance the consistency of Demirjian's classification system.

LIMITATION AND RECOMMENDATION OF THE STUDY

The study recommends standardized training for observers to minimize variability in applying Demirjian's classification system. Although agreement between observers was high, significant differences suggest the need for consistent training. Combining this technique with other age estimation methods, such as skeletal assessments, could improve accuracy. Expanding the sample size and including diverse ethnic groups would enhance generalizability, while future studies on younger age groups and advanced imaging techniques like CBCT could improve precision. However, the study has limitations. Observer variability, a limited age range, and the exclusion of genetic and ethnic factors restrict the findings' broader applicability. Relying solely on dental radiographs without skeletal assessments may affect age estimation accuracy, and using only OPGs might have reduced image quality and precision.

REFERENCES

1) **Lawn BR, Lee JJ-W, Chai HJARoMR. Teeth: among nature's most durable biocomposites. 2010;40(1):55-75.**
2) **Milani OH, Atici SF, Allareddy V, Ramachandran V, Ansari R, Cetin AE, et al. A fully automated classification of third molar development stages using deep learning. 2024;14(1):13082.**
3) **Zigante M, Pavlic A, Morelato L, Vandevska-Radunovic V, Spalj SJIjoer, health p. Presence and maturation dynamics of mandibular third molars and their influence on late mandibular incisor crowding: a longitudinal study. 2021;18(19):10070.**

4) **Patil MA, Tivaskar MS, Luharia MA, Dhande R, Pathade AJJoPNR. Age Estimation Using Digital Radiography Of Epiphysial Union Of Shoulder Joint. 2022:23-9.**
5) **Nino-Sandoval TC, Doria-Martinez AM, Escobar RAV, Sánchez EL, Rojas IB, Álvarez LCV, et al. Efficacy of the methods of age determination using artificial intelligence in panoramic radiographs—a systematic review. 2024:1-38.**
6) **Sezer B, Çarıkçıoğlu B, Kargül BJAoOB. Dental age and tooth development in children with molar-incisor hypomineralization: A case-control study. 2022;134:105325.**
7) **Phulari RG, Dave EJJEJoFS. Evolution of dental age estimation methods in adults over the years from occlusal wear to more sophisticated recent techniques. 2021;11:1-14.**
8) **Siqueira R, Fernandes G, Di Gianfilippo R, Wang JCJSFOTAIA. Evolution, Development, and Physiology of the Dentoalveolar Bone Evolution of the Human Jawbone and Dentoalveolar Bone Dentoalveolar bone, as part of the jaw and skull bone, is an. 2023:299.**
9) **Caggiano M, Scelza G, Amato A, Orefice R, Belli S, Pagano S, et al. Estimating the 18-Year threshold with third molars radiographs in the Southern Italy population: Accuracy and reproducibility of demirjian method. 2022;19(16):10454.**
10) **Han M-q, Jia S-x, Wang C-X, Chu G, Chen T, Zhou H, et al. Accuracy of the Demirjian, Willems and Nolla methods for dental age estimation in a northern Chinese population. 2020;118:104875.**
11) **Angelakopoulos N, Chaitanya NC, Balla SBJAoLM. Effect of impaction on third molar development and age estimation–A study in a female black South African population. 2024:200477.**
12) **Bozorgnia Y, Mafinejad S, Dokohaki S, Razavi N, Shabani RJCOI. The effect of birth weight on tooth development by Demirjian's method. 2024;28(7):411.**
13) **Bunyarit SS, Nambiar P, Naidu MK, Ying RPY, Asif MKJPDJ. Dental age estimation of Malay children and adolescents: Chaillet and Demirjian's data improved using artificial multilayer perceptron neural network. 2021;31(2):176-85.**
14) **Farrington DP, Piquero AR, Jennings WG, Jolliffe D. Offending from childhood to late middle age: Recent results from the Cambridge study in delinquent development: Springer Nature; 2023.**
15) **Plascencia H, Díaz M, Ordinola-Zapata R, Vázquez-Sánchez ME, Juárez-Broon N, Ruíz-Gutiérrez A, et al. Intra-and interobserver agreement during the assessment of the different stages of root development using 4 radiographic classifications. 2021;47(6):906-13.**
16) **Hedge C, Powell G, Sumner PJBrm. The reliability paradox: Why robust cognitive tasks do not produce reliable individual differences. 2018;50:1166-86.**
17) **Toledo JP, Yermani RR, Pinto AO, Conejeros RVJFSIR. Development of the third molar in Chileans: A radiographic study on chronological age. 2021;3:100177.**
18) **De Micco F, Martino F, Velandia Palacio LA, Cingolani M, Campobasso CPJM, Science, Law t. Third molar maturity index and legal age in different ethnic populations: Accuracy of Cameriere's method. 2021;61(1_suppl):105-12.**

19) **Abdullah NA-W, Al-Aghbari BA, Mokbel AHAJUoAJoN, Sciences A. Radiographic evaluation of third molars development in relation to chronological age among children and youth in Aden city. 2020;24(1):251-61.**
20) **Kasper KA, Austin D, Kvanli AH, Rios TR, Senn DRJJofs. Reliability of third molar development for age estimation in a Texas Hispanic population: a comparison study. 2009;54(3):651-7.**