RESEARCH PAPER

REFINING FORENSIC AGE ESTIMATION USING A NOVEL CLASSIFICATION SYSTEM FOR MANDIBULAR THIRD MOLAR ERUPTION IN PANORAMIC RADIOGRAPH - A RETROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background

Age estimation through assessment of the dentition is an application distinctive to forensic odontology. Among the criteria of developmental morphology, tooth eruption can be evaluated either by clinical examination or through the interpretation of dental radiographs to establish the dental age. This study aims to estimate age using a novel classification system for mandibular third molar eruption on panoramic radiographs.

Materials and Methods

A total of 433 OPGs from individuals aged 15 to 25 years, in which both mandibular third molars were radiographically assessable, were included in this study. Third molar eruption was evaluated by two independent observers according to the new classification system. The mean, median, and minimum ages corresponding to each stage of mandibular third molar eruption were then recorded.

Results

Of the 433 OPGs assessed (199 males, 234 females), the overall mean age was 21.10 ± 2.61 years. Mean age rose progressively from Stage 1 (≈16.3 years) to Stage 6 (≈22.5 years), confirming that advancing eruption corresponds to increasing age. Stage 5 was the most frequently observed eruption stage on both sides, whereas Stage 1 was the least common. Eruption patterns were closely comparable between the right and left sides and between the sexes, indicating bilateral and inter-sex consistency.

Conclusion

Measuring the distance of the mandibular third molar from a simplified occlusal plane on panoramic radiographs is a promising approach for assessing eruption status in forensic age estimation. By incorporating finer, more clearly defined eruption stages, the new classification system allows more precise age assessment than existing methods and offers a non-invasive, cost-effective tool for forensic practice. Further validation in larger and more diverse populations is warranted to confirm its reliability across age ranges and demographic groups.

Keywords: Age Determination by Teeth; Forensic Dentistry; Molar, Third; Tooth Eruption; Radiography, Panoramic; Dental; Technology.

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INTRODUCTION

Forensic age assessment of living individuals provides legal certainty in cases where a person's chronological

age is unknown or age-related documentation is unreliable. It therefore holds particular relevance within legal proceedings and administrative procedures [1-4]. In line with the recommendations of the Study Group on Forensic Age Diagnostics (AGFAD) for age estimation in the living, multiple methods should be applied in combination, with a dental examination forming an essential component of the process [5]. This approach enables the age of the individual under evaluation to be estimated within a defined margin of error.

Tooth eruption refers to the process through which a tooth moves from its initial developmental site within the bony jaw to its functional position in the oral cavity. This process is governed mainly by genetic factors, with additional influence from the local environment [6]. For descriptive convenience, eruption has been divided into five distinct phases: the pre-eruptive stage, the intra-osseous stage, the mucosal penetration stage, the pre-occlusal stage, and the post-occlusal stage [7].

In current practice, the term "dental age estimation" (DAE) has been adopted to encompass additional age-related dental characteristics beyond eruption alone. The principle of DAE continues to form an integral part of present-day recommendations for evidence-based age assessment [8]. Consistent with these recommendations, the process should include, among other investigations, a radiographic examination of the dentition [5].

Because the question of whether an individual has reached the age of majority is often the central concern in present-day legal proceedings, assessment typically focuses on the third molars, as these are the last teeth to complete development and the age of majority coincides with the period in which their development concludes [9]. In particular, the mineralisation and eruption of the mandibular third molars are evaluated. These findings are subsequently compared with corresponding reference populations to estimate the individual's chronological age, within an accepted margin of statistical uncertainty [2].

Third molar eruption can be evaluated both clinically and radiologically. For many years, the clinical emergence of the third molars into the oral cavity served as an important indicator in age assessment [10–12]. When radiographs are examined, however, it becomes possible to also account for conditions preceding gingival emergence, chiefly the alveolar bone overlying the tooth crown [13]. Several staging methods have been proposed for evaluating mandibular third molar eruption on radiographs [9, 14-16], and these classifications vary in particulars such as their reference points or the level of detail in their descriptions. Considering this, the present study aims to estimate age using a novel classification system for mandibular third molar eruption on panoramic radiographs.

MATERIALS AND METHOD

Study design

This was a retrospective observational study based on archived panoramic radiographs.

Setting

This study was conducted at a private dental college and hospital, where the orthopantomograms (OPGs) were retrieved from the archives of the Department of Oral Medicine and Radiology. OPGs belonged to patients visiting various dental departments that were exposed as part of a routine investigation. Data were collected from January 2024 to December 2025.

Participants

Digital orthopantomograms were drawn from an approximately equal number of male and female individuals aged 15 to 25 years. Records were eligible when the radiograph was of adequate diagnostic quality, and both mandibular third molars were clearly identifiable. Radiographs with a missing mandibular third molar, any form of eruption disturbance, impacted were excluded from the study. After these criteria were applied, the final sample comprised 433 OPGs (199 males and 234 females).

Variables

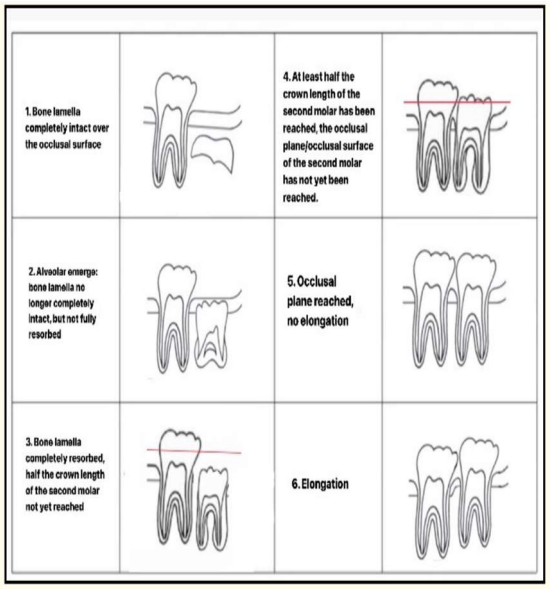
The primary predictor variable was the eruption stage of the mandibular third molar, categorised according to the new six-stage classification (see Figure 1). The outcome of interest was chronological age at the time of radiographic examination. Side (right and left) and sex were recorded as additional variables.

Figure 1: New classification system for third molar eruption by Timme et al 2024 (22)

Data measurement

Each individual's chronological age at the time of the radiographic examination was ascertained from the records. Radiographs were reviewed in DICOM format at dedicated reporting workstations. Third molar eruption was graded using the following classification proposed by *Timme* et al.:

1. Bone lamella completely intact over the occlusal surface (Figure 2)
2. Alveolar emerge: bone lamella no longer completely intact, but not fully resorbed (Figure 3)



3. Bone lamella completely resorbed, half the crown length of the second molar not yet reached (Figure 4)
4. At least half the crown length of the second molar has been reached, the occlusal plane/occlusal surface of the second molar has not yet been reached (Figure 5)
5. Occlusal plane reached, no elongation (Figure 6)
6. Elongation (Figure 7)

Figure 2 depicts Stage 1 of the eruption on both sides

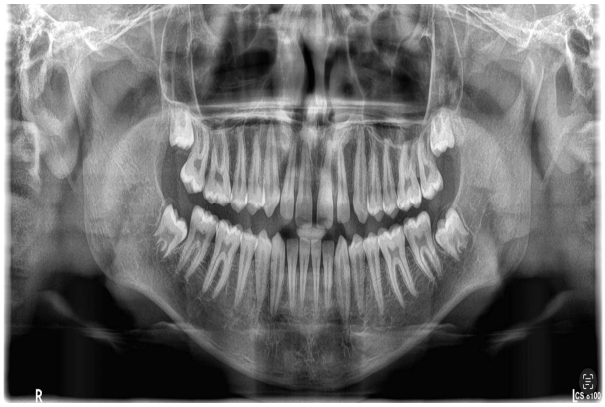


Figure 3 depicts Stage 2 of the eruption on both sides

Figure 4 depicts Stage 3 of the eruption on both sides

Figure 5 depicts Stage 4 of the eruption on both sides

Figure 6 depicts Stage 5 of the eruption on both sides

Figure 7 depicts Stage 6 of the eruption on both sides

Bias

To limit observer bias, all radiographs were assessed independently by two examiners and presented in randomised order during the primary evaluation, with each observer blinded to the other's gradings. The predefined inclusion and exclusion criteria were applied uniformly to reduce selection bias.

Quantitative variables

Chronological age was treated as a continuous variable expressed in years, while the third molar eruption stage was handled as an ordinal variable spanning the six categories defined above. Findings were stratified by side and by sex.

Statistical analysis

Descriptive statistics—mean, median, minimum, and standard deviation—were calculated for chronological age at each eruption stage, separately for the right and left sides and for male and female participants. The frequency and percentage of participants within each stage were also determined using the Statistical Package for the Social Sciences (SPSS version 26.0)

RESULTS

Table 1 presents the mean age and standard deviation of all participants according to different stages of third molar eruption on both right and left sides. The mean age showed a progressive increase from Stage 1 to Stage 6, indicating advancement of eruption with age. The highest number of participants was observed in Stage 5. Similar eruption patterns were noted on both sides, demonstrating bilateral consistency.

Side	Stage	N	Mean	SD	Minimum	Maximum
Right	1	4	16.25	1.26	15	16
	2	66	19.48	2.62	15	26
	3	99	20.17	2.67	15	26
	4	62	22.23	2.41	17	28
	5	149	21.58	2.17	15	29
	6	53	22.53	1.77	17	25
Left	1	4	16.25	1.26	15	18
	2	60	19.07	2.60	15	26
	3	88	20.33	2.74	15	26
	4	57	22.39	2.32	15	29
	5	169	21.42	2.17	17	28
	6	55	22.58	1.73	17	27

Table 1: Mean age and standard deviation of participants across various stages of eruption stages

Table 2 describes the mean age distribution of male participants across various stages of third molar eruption. A gradual increase in mean age was observed from Stage 1 to Stage 6 on both right and left sides. Stage 5 included the maximum number of participants. The standard deviation values indicated moderate variability within stages, while the eruption pattern remained almost symmetrical bilaterally among male subjects.

Side	Stage	N	Mean	SD	Minimum	Maximum
Right	1	3	15.67	.58	15	16
	2	23	19.39	2.39	15	23
	3	44	19.66	2.67	15	25
	4	29	21.93	2.60	18	28
	5	77	21.57	2.49	15	29
	6	23	23.13	1.01	21	24
Left	1	3	15.67	.58	15	16
	2	22	18.77	2.11	15	24
	3	35	19.74	2.87	15	25
	4	28	22.46	2.82	15	29
	5	80	21.21	2.30	18	28
	6	31	22.90	1.42	21	27

Table 2: Mean age and standard deviation of male participants across various stages of eruption stages

Table 3 shows the mean age and standard deviation of female participants in relation to stages of third molar eruption. Mean age increased progressively with advancing eruption stages on both sides. The majority of female participants belonged to Stage 5, followed by Stage 3. Bilateral comparison revealed comparable mean ages and eruption stages between right and left sides, suggesting uniformity in eruption timing among female participants.

Side	Stage	N	Mean	SD	Minimum	Maximum
Right	1	1	18.00	-	18	18
	2	43	19.53	2.76	15	26
	3	55	20.58	2.63	16	26
	4	33	22.48	2.22	17	26
	5	72	21.60	1.78	17	25
	6	30	22.07	2.08	17	25
Left	1	1	18.00	-	18	18
	2	38	19.24	2.86	15	26
	3	53	20.72	2.60	16	26
	4	29	22.31	1.76	18	26
	5	89	21.61	2.04	17	25
	6	24	22.17	2.01	17	25

Table 3: Mean age and standard deviation of female participants across various stages of eruption stages

Table 4 summarises the stage-wise frequency of male, female, and total participants. Females constituted a slightly higher proportion of the study population compared to males. Stage 5 represented the most common eruption stage on both sides, whereas Stage 1 showed the least frequency among participants.

Stage	**Male**		**Female**		**Total**	
	Right	***Left***	***Right***	***Left***	***Right***	***Left***
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)

1	3 (1.5)	3 (1.5)	1 (0.4)	1 (0.4)	4 (0.9)	4 (0.9)
2	23 (11.6)	22 (11.1)	43 (18.4)	38 (16.2)	66 (15.2)	60 (13.9)
3	44 (22.1)	35 (17.6)	55 (23.5)	53 (22.6)	99 (22.9)	88 (20.3)
4	29 (14.6)	28 (14.1)	33 (14.1)	29 (12.4)	62 (14.3)	57 (13.2)
5	77 (38.7)	80 (40.2)	72 (30.8)	89 (38.0)	149 (34.4)	169 (39.0)
6	23 (11.6)	31 (15.6)	30 (12.8)	24 (10.3)	53 (12.2)	55 (12.7)

Table 4: Distribution of participants across various stages of eruption stages

DISCUSSION

Forensic age estimation is frequently required in legal and humanitarian settings, most often when it must be established whether an individual has reached the age of majority. The mandibular third molar is widely employed for this purpose because it is the last tooth to complete development, and its maturation spans the legally critical interval between approximately 17 and 25 years. In the present study, the mean participant age increased progressively from Stage 1 to Stage 6 of third molar eruption on both sides, and this gradient was reproduced in both sexes. The stepwise rise indicates that the staging captures a genuine biological progression and supports the use of the classification for age estimation in the population examined.

The six-stage classification applied here was the system derived by Timme et al. (2023) [17], who proposed it as a refinement specifically adapted to radiographic conditions. Their scheme builds upon the modified classification of Olze et al. (2012) by describing resorption of the bone lamella overlying the developing tooth in greater detail, distinguishing partial from complete resorption and thereby subdividing the early eruptive phase. Because it resolves eruption into more steps than earlier systems—six rather than the four or five of comparable methods—it was expected to afford finer discrimination of age during the years in which third molar eruption is most active.

When Timme et al. evaluated this classification against the methods of Olze et al. (2012) [15] and Willmot et al. (2018) [14] in 211 individuals aged 15 to 25 years, the correlation between stage and age for the new method was moderate and sex-dependent, with Spearman coefficients of approximately 0.58 in males and 0.45 in females. Among female participants, the new classification yielded the highest correlation and the greatest proportion of explained variance of the three systems tested. Its inter-rater agreement, however, was marginally lower than that of the older methods, a finding the authors attributed in part to the additional stages demanding finer distinctions between examiners. They concluded that, although the system performed comparably overall, no clear statistical advantage over the established Olze method could be demonstrated in their cohort [15]. The progressive age gradient observed in the present study is consistent with the moderate stage–age association and extends the application of the classification to a different population.

In keeping with the originating study, the association between eruption stage and age tended to be stronger in males than in females, a pattern frequently reported for third molar development and commonly attributed to sexual dimorphism in the timing of maturation [18, 19]. In the present cohort, mean ages and stage distributions were broadly comparable between the sexes and between the right and left sides, suggesting that the classification can be applied symmetrically and that a single mandibular third molar may suffice when its contralateral counterpart is unavailable or cannot be assessed.

Eruption timing is known to differ between populations and ethnic groups, which necessitates population-specific reference data for accurate estimation. The eruption of the third molar is governed mainly by genetic factors, with external influences playing a comparatively minor role, although mechanical obstruction such as impaction can disturb the normal sequence and must therefore be excluded [20, 21]. By reporting stage-specific ages in a South Indian sample, the present study contributes population-relevant data that complement the German cohort of Timme et al. and other recently published reference datasets [21].

As with most investigations in dental age estimation, the present material constituted a convenience sample: ethical restrictions on radiation exposure preclude the prospective, random recruitment of healthy individuals, so radiographs obtained for clinical indications must be used. This design inherently limits the extent to which the sample represents the general population. Nevertheless, because the aim was to evaluate the staging system rather than to generate definitive reference standards, and because any selection effect would apply uniformly across the

stages, the influence of this limitation is expected to be modest.

Overall, the present findings support the applicability of the six-stage radiographic classification of Timme et al. for third molar eruption in forensic age assessment, while underscoring that its principal theoretical strength finer resolution through additional stages has not yet translated into a demonstrable gain in accuracy over established methods. Further validation in larger and more demographically diverse samples, ideally incorporating quantified measures of inter- and intra-observer agreement, will be required before the system can be recommended for routine practical use.

CONCLUSION

Within the South Indian sample examined, the six-stage radiographic classification of mandibular third molar eruption showed a consistent progression of mean age from Stage 1 to Stage 6 on both sides and in both sexes, supporting its applicability to forensic age estimation. By resolving the eruption into finer stages, the system offers a non-invasive and economical means of assessing the eruption status from panoramic radiographs. Since eruption timing varies across populations, these stage-specific values contribute useful population-relevant reference data. Further validation in larger and more diverse samples, incorporating quantified measures of observer agreement, is warranted before the classification can be recommended for routine practical use.

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Conflict of Interest:

Nil.

Informed consent:

Informed consent forms were obtained from the patients to utilize their orthopantamograms for research purposes.

Ethical clearance:

Ethical clearance was waived given the retrospective nature of the study.

REFERENCES

1. Mansour H, Fuhrmann A, Paradowski I, van Well EJ, Püschel K (2017) The role of forensic medicine and forensic dentistry in estimating the chronological age of living individuals in Hamburg, Germany. Int J Legal Med 131:593–601.
2. Schmeling A, Dettmeyer R, Rudolf E, Vieth V, Geserick G (2016) Forensic age estimation. Dtsch Arztebl Int 113:44–50.
3. Schmeling A, Geserick G, Reisinger W, Olze A (2007) Age estimation. Forensic Sci Int 165:178–181.
4. Schmeling A, Reisinger W, Geserick G, Olze A (2006) Age estimation of unaccompanied minors. Part I. General considerations. Forensic Sci Int 159(Suppl 1):S61-64.
5. Schmeling A, Grundmann C, Fuhrmann A, Kaatsch H-J, Knell B, Ramsthaler F, Reisinger W, Riepert T, Ritz-Timme S, Rösing FW, Rötzscher K, Geserick G (2008) Criteria for age estimation in living individuals. Int J Legal Med 122:457–460.
6. Kreiborg S, Jensen BL. Tooth formation and eruption - lessons learnt from cleidocranial dysplasia. Eur J Oral Sci 126 Suppl. 2018;172–80.
7. Andreasen JO, Petersen JK, Laskin DM. Textbook and color atlas of tooth impactions: diagnosis, treatment, prevention. St Louis, Mo: Mosby Year Book Inc.; 1997.
8. Merdietio Boedi R, Mânica S, Franco A. Sixty years of research in dental age estimation: a bibliometric study. Egypt J Forensic Sci. 2023;13:41.
9. AlQahtani SJ, Hector MP, Liversidge HM. Brief communication: the London atlas of human tooth development and eruption. Am J Phys Anthropol. 2010;142:481–90.
10. Rantanen AV (1967) The age of eruption of the third molar teeth. Acta Odontol Scand 25:1–86
11. Levesque GY, Demirijian A, Tanguay R (1981) Sexual dimorphism in the development, emergence, and agenesis of the mandibular third molar. J Dent Res 60:1735–1741.
12. Chagula WK (1960) The age at eruption of third permanent molars in male East Africans. Am J Phys Anthropol 18:77–82.
13. Haavikko K (1970) The formation and the alveolar and clinical eruption of the permanent teeth. An orthopantomographic study. Suom Hammaslaak Toim 66:103–170
14. Willmot SE, Hector MP, Liversidge HM (2018) Accuracy of estimating age from eruption levels of mandibular teeth. DAJ 26:56–62.
15. Olze A, Peschke C, Schulz R, Schmeling A (2012) Application of a modified stage classification in evaluating wisdom tooth eruption in a German population. Archiv Kriminol 229:145–153

16. Gambier A, Rérolle C, Faisant M, Lemarchand J, Paré A, Saint- Martin P (2019) Contribution of third molar eruption to the estimation of the forensic age of living individuals. Int J Legal Med 133:625–632.
17. Timme M, Viktorov J, Steffens L, Streeter A, Karch A, Schmeling A. Third molar eruption in orthopantomograms as a feature for forensic age assessment—a comparison study of different classification systems. International Journal of Legal Medicine. 2023 May;137(3):765-72.
18. Vadivel MK, Pydi HS, Gurugubelli S, Pedada RK, Varma MR. STUDY ON CLINICAL STAGING OF THIRD MOLAR ERUPTION AS AN AID IN AGE ESTIMATION. Int J Acad Med Pharm. 2025;7(4):1063-6.
19. Putul M, Konwar R, Dutta M, Basumatary B, Rajbongshi MC, Thakuria KD, Sarma B. Assessment of Age at the Stages of the Eruption of Third Molar Teeth among the People of North-Eastern India. Biomed Res Int. 2021 Dec 30;2021:9714121
20. Mahanta P Sr, Das K, Deka H, Basumatari B, Konwar R, Mazumder P, Rajbanshi MC. Relationship Between the Eruption of Third Molar Teeth and the Growing Status of the Assamese Inhabitants of a North-Eastern State of India. Cureus. 2022 Jan 9;14(1):e21044.
21. Timme M, Viktorov J, Steffens L, Streeter A, Karch A, Schmeling A. Third molar eruption in dental panoramic radiographs as a feature for forensic age assessment - new reference data from a German population. Head Face Med. 2024 May 10;20(1):29.
22. Timme M, Viktorov J, Steffens L, Streeter A, Karch A, Schmeling A. Third molar eruption in dental panoramic radiographs as a feature for forensic age assessment - new reference data from a German population. Head Face Med. 2024 May 10;20(1):29.