# Evaluation of mandibular third molar for age estimation of Filipino population age 9 – 23 years

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The authors declare that they have no conflict of interest.

KEYWORDS

Age estimation,
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## ABSTRACT

***Objectives:*** The study aims to determine the correlation between dental age and chronologic age in the assessment of third molar development among Filipino patients aged 9 to 23 years seen in the Paediatric Dentistry Division (PDD) of the Philippine Children's Medical Centre (PCMC) between 2012-2017.

***Materials and Methods:*** 384 digital panoramic radiographs of Filipino patients (215 males and 169 females) were gathered. Right mandibular third molars were assessed using Modified Demirjian Scoring System. Mean Absolute Error, Percentage error and Correlation is determined between dental age (DA) and chronologic age (CA) of the population.

***Results and Conclusion:*** Initial development of the third molars is observed to begin at approximately 9 years of age and root completion commences at around 19 years of age. Using Spearman Rank-Order Correlation, a strong positive correlation between CA and DA was observed among the overall population (r=0.9518). The observed correlation was stronger among females (r=0.9595) compared to males (r=0.9445). All correlation coefficients were significant (p-value<0.0001). Low percentage error among males and females is observed indicating no significant difference between the CA and DA values of the population.

## INTRODUCTION

Age estimation in forensic medicine aims to determine the chronologic age of a person in the most accurate way.[1] Following legal proceedings, age estimation is usually used in cases of orphaned or abandoned children, of determining legal liabilities as stated in the law[2] and of identifying an unknown body or corpse.[3] There are many tools available to aid in age estimation; these include use of radiographic examination of hands and wrists,[4] epiphyseal fusion of long bones,[5] cervical vertebrae,[6] pubic symphysis[7] and skull suture's fusion.[8] Along with these, studies have also pointed out the associations of dentition with age estimation[9,10] and was found to be an even more reliable indicator of biological maturity in children since it is less affected by an individual's nutritional and endocrine condition.[11] Throughout the decades, methods of age estimation using the dentition have been developed which include morphological, biochemical and radiographic methods. Morphological methods assess extracted teeth prepared microscopically. Biochemical methods assess teeth based on specific amino acids that are at an increased level with age.

Radiographic methods assess teeth through different radiographic images.[12,13] Of these methods, radiographic assessment is the simplest, least invasive, most reproducible and cheapest means to estimate age.[14] But when all permanent teeth have erupted, age estimation becomes challenging leaving the third molars as the only basis for age estimation. Noting its varied formation, eruption and calcification stages, a study on its correlation with chronologic age is necessary.

The purpose of the study is to assess the difference and determine the correlation between dental age and chronologic age in the assessment of third molar development among Filipino patients of the Philippine Children's Medical Centre aged 9 to 23 years. Since studies have shown racial differences[15,16] in tooth formation and development, it is important to establish if such a correlation exists within the population.[17]

## MATERIALS AND METHODS

The study is a quantitative analytical cross-sectional type aiming to observe the difference and correlation of dental age with chronologic age in the assessment of third molar development among Filipino patients aged 9 to 23 years seen in the Paediatric Dentistry Division (PDD) of the Philippine Children's Medical Centre (PCMC) between 2012-2017

*Sample and Sampling Design*

The study involved Filipino patients who had their digital panoramic radiograph taken by the Paediatric Dentistry Division of the Philippine Children's Medical Centre between 2012-2017. All panoramic radiographs of the sample population were gathered from the database of the said institution.

A total of 384 panoramic radiographs, with 215 males and 169 females were included in the study. Table 1 shows the summary of distribution of samples according to age and sex while Table 2 shows distribution according to age with Mean ± Standard Deviation.

**Table 1.** Distribution of Samples According to Age and Sex

| Chronologic Age | Male | Female | Total |
|---|---|---|---|
| 9 | 17 | 20 | 37 |
| 10 | 31 | 14 | 45 |
| 11 | 22 | 14 | 36 |
| 12 | 19 | 14 | 33 |
| 13 | 12 | 12 | 24 |
| 14 | 18 | 8 | 26 |
| 15 | 12 | 10 | 22 |
| 16 | 13 | 9 | 22 |
| 17 | 17 | 9 | 26 |
| 18 | 10 | 10 | 20 |
| 19 | 12 | 7 | 19 |
| 20 | 8 | 7 | 15 |
| 21 | 9 | 17 | 26 |
| 22 | 7 | 8 | 15 |
| 23 | 8 | 10 | 18 |
| **Total** | **215** | **169** | **384** |

**Table 2.** Distribution according to sex and age with mean ± standard deviation

| | Total (N=384) Mean ± SD |
|---|---|
| Chronologic Age | 14.81. ± 4.35 |
| Dental Age (Using Modified Demirjian Scoring System) | 82. ± 2.55 |

*Description of the Study Procedure*

Approval from PCMC Institutional Research Board – Ethics Committee and UP Manila Research Ethics Board to conduct the study

was obtained. After which, the records custodian of the Paediatric Dentistry Division of the Philippine Children's Medical Centre was asked to gather soft copies of the patients' digital panoramic radiographs taken between 2012-2017 (using Vatech Pax-C Digital Panoramic X-ray Machine) from the patient database and its corresponding patients' charts. Assistant researcher 1 (AR1) kept all soft copies of the digital panoramic radiographs in a USB Flash drive. Following the inclusion and exclusion criteria, AR1 identified the radiographs and labeled each from 1 to 384. Inclusion and exclusion criteria are as follows:

*Inclusion criteria:*
- Filipino patients aged 9 to 23 years
- Patients without history and/or pre-existing medical condition
- Radiographically sound tooth #48

*Exclusion criteria:*
- Patients with recorded or history of serious medical illness
- Patients with congenitally missing, either one or both, mandibular third molars
- Those in whom tooth #48 has a restoration or cavity or presence of periapical infection as seen on the digital panoramic radiograph
- Children with existing or with history of physical trauma on the face

Rotated tooth #48 were also excluded from the study due to difficulty in assessing crown and root development. Information from the panoramic radiographs included in the study were encoded in an MS Excel Sheet including: assigned radiograph number, sex, date of birth, nationality and date the radiograph was taken. Chronologic age (CA) was also encoded by subtracting the date of birth from the date the radiograph was taken. After encoding, AR1 removed all personal information visible from the digital panoramic radiographs in such a way that only the panoramic image was left for the Primary Investigator (PI) to analyze.

All gathered data were saved in AR1's laptop that was secured with a password, copied to a USB Flash drive and a duplicate was sent to AR1's electronic mail. Data were kept with utmost care by AR1.

*Calibration*

AR1 gave 100 randomly selected digital panoramic radiographs to the PI and Assistant Researcher 2 (AR2). The PI and AR2 separately assessed tooth #48 using the Modified Demirjian Scoring System[18,19] viewed in a MacBook Air laptop with 100% brightness. Data were encoded in an MS Excel Sheet and were sent separately to AR1 for safekeeping. Data gathered were then sent to the statistician for analysis of inter-rater agreement through Cohen's Kappa.

*Panoramic Radiograph Interpretation*

After calibration, the PI scored all Tooth #48 with a maximum of 100 radiographs a day, to avoid fatigue. The developmental stage of third molars was determined using the Modified Demirjian Scoring System. Each stage had its numerical value for statistical analysis. The assessment took four days in total. Data collected were recorded in an MS Excel Sheet and then sent to the biostatistician for analysis.

*Ethical Considerations*

Ethical approval and authorization to conduct the study and exemption to obtain informed consent were sought from the independent local Institutional Review Board-Ethics Committee (IRB-EC) of PCMC.

Good Clinical Practice (GCP) / Principles of Helsinki was observed throughout the study. All data gathered were treated with utmost confidentiality and were safely stored to ensure data privacy.

All data gathered will be discarded, in accordance to the Philippine Data Privacy Act of 2012 and NEGHRR 2017, in a secure manner to prevent unauthorized access by any party or the public.

*Data Processing and Analysis*

Data gathered were summarized in tables for interpretation of results. A biostatistician assisted in the statistical analysis of the data obtained. Kappa Analysis was used to determine inter-rater agreement. Spearman's Rank-Order Correlation was used to determine the relationship between chronologic age and dental age. Level of significance was set at 0.01. Correlation analysis was conducted using Stata MP ver. 12. Mean Absolute Error and Percentage Error of the population were also computed and tabulated.

**Table 3.** Distribution according to sex and age with mean ± standard deviation

| Two examiners | Intra-class correlation | 95% Confidence Interval | | F test with true value= 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Significant |
| Single measures | 0.995 | 0.993 | 0.997 | 409.27 | 94 | 95 | p-value <0.001 |
| Average measures | 0.998 | 0.996 | 0.998 | | | | |

## RESULTS

100 of the 384 radiographs were randomly selected by AR1 for calibration between the PI and AR2. Inter-rater agreement was analyzed through Kappa Analysis and an agreement of >93% with a p-value <0.0001 was achieved. Inter-rater correlation coefficient is shown in Appendix C.

Table 4 shows the summary of ratings of the raters and Cohen's Kappa. A minimum of 90% inter-rater agreement was targeted in the study. Calibration results achieved a >93% inter-rater agreement that demonstrates a high agreement between the PI and AR2.

**Table 4.** Summary of Ratings of the Raters and Cohen's Kappa

| | Rater 1 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Rater 2** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **Total** |
| **1** | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| **2** | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| **3** | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| **4** | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 13 |
| **5** | 0 | 0 | 0 | 1 | 12 | 1 | 0 | 0 | 0 | 14 |
| **6** | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| **7** | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 11 |
| **8** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 14 |
| **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 12 |
| Total | 7 | 9 | 11 | 14 | 16 | 1 | 11 | 14 | 12 | 95 |

| Percentage Agreement | Kappa | Std. Err. | p-value |
|---|---|---|---|
| 93.68% | 0.9279 | 0.0383 | <0.0001 |

Among the 384 panoramic radiographs:
Stage 0 is observed in ages 9 to 11 years.
Stage A is observed in 9 to 13 years of age.
Stage B is observed in 10 to 13 years of age.
Stage C is observed in 12 to 15 years of age.
Stage D is observed in 13 to 16 years of age.
Stage E is observed in age 13 to 21 years of age; however, it is noted that there is no developmental stage at ages 14, 19 and 20, possibly due to lack of samples assessed. Stage F is observed in ages 15 to 23 years. Stage G is observed in ages 16 to 23 years. Stage H is observed in ages 19 to 23 years. Table 5 shows the summary of age distribution per development stage of tooth #48.

Correlation was determined using Spearman Rank-Order Correlation Analysis to describe strength of association between two variables, Chronologic Age (CA) and Dental Age (DA). Table 6 shows results of the correlation. A strong positive correlation between Chronological Age (CA) and Dental Age (DA) was observed among the overall population (r=0.9518). The observed correlation was stronger among females (r=0.9595) compared to males (r=0.9445). All correlation coefficients were significant (p-value < 0.0001).

Mean Absolute Error of 1.05 and 1.06 and percentage error of 7.49 and 7.43 is observed within the male and female population, respectively, as shown in Table 7.

**Table 5.** Summary of Age Distribution per Developmental Stage of Tooth #48

| | Developmental Stage | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | **o** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **Total No. of Teeth** |
| 9 | 31 (83.8%)[a] | 6 (16.2%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 |
| 10 | 24 (53.3%) | 11 (24.4%) | 10 (22.2%) | 0 | 0 | 0 | 0 | 0 | 0 | 45 |
| 11 | 4 (11.1%) | 17 (47.2%) | 15 (41.7%) | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| 12 | 0 | 10 (30.3%) | 9 (27.3%) | 14 (42.4%) | 0 | 0 | 0 | 0 | 0 | 33 |
| 13 | 0 | 1 (4.2%) | 8 (33.3%) | 8 (33.3%) | 5 (20.8%) | 2 (8.3%) | 0 | 0 | 0 | 24 |
| 14 | 0 | 0 | 0 | 14 (53.8%) | 12 (46.2%) | 0 | 0 | 0 | 0 | 26 |
| 15 | 0 | 0 | 0 | 1 (4.5%) | 8 (36.4%) | 10 (45.5%) | 3 (13.6%) | 0 | 0 | 22 |
| 16 | 0 | 0 | 0 | 0 | 10 (455%) | 8 (36.4%) | 3 (13.6%) | 1 (4.5%) | 0 | 22 |
| 17 | 0 | 0 | 0 | 0 | 0 | 15 (57.7%) | 10 (38.5%) | 1 (3.8%) | 0 | 26 |
| 18 | 0 | 0 | 0 | 0 | 0 | 5 (25%) | 14 (70%) | 1 (5%) | 0 | 20 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 10 (52.6%) | 8 (42.1%) | 1 (5.3%) | 19 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 9 (60%) | 5 (33.3%) | 1 (7.7%) | 15 |
| 21 | 0 | 0 | 0 | 0 | 0 | 2 (7.75%) | 9 (34.6%) | 7 (26.9%) | 8 (30.8%) | 26 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (13.3%) | 7 (46.75% | 6 (40%) | 15 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (5.6%) | 3 (16.7%) | 14 (77.8%) | 18 |
| Total No. of Teeth | 59 | 45 | 42 | 37 | 35 | 42 | 61 | 33 | 30 | **384** |

[a] Percentage of total number of teeth at that age

**Table 6.** Spearman Rank-Order Correlation for Males and Females

| **Correlation between DA and CA** | **Males** | **Females** | **Overall** |
|---|---|---|---|
| Spearman correlation coefficient | 0.9445 | 0.9595 | 0.9518 |
| p-value (2-tailed) | <0.0001 | <0.0001 | <0.0001 |
| N | 215 | 169 | 384 |

**Table 7.** Mean Absolute Error and Percentage Error for Males and Females

| | Mean Absolute Error | Percentage Error |
|---|---|---|
| Males (n=215) | 1.05 | 7.49 |
| Females (n=169) | 1.06 | 7.43 |

## DISCUSSION

The study showed a strong positive correlation between the Dental Age and Chronologic Age using the Modified Demirjian Scoring System among the study population. The association can be described that the chronologic age and dental age are directly proportional to each other. The observed correlation was strong in the population with females having r=0.9595 and males with r=0.9445 (p<0.0001). Studies conducted among South Indian,[20,21] Thai,[22] Israeli,[23] Spanish,[24] and Nigerian[25] populations revealed the same correlation results. The study of Mohammed[21] in 2014 found that third molar root development can be used to generate an age range for an individual of unknown chronologic age. Sarnat et al. concludes that indeed a high correlation is found between third molar development and chronological age.[23] Study results are consistent with other population based studies. [20-25]

Within the study population, initial formation begins at 9 years of age and root completion starts from 19 to 23 years of age.

The study of Mohammed, et al. among the South Indian population showed that initial formation occurred at mean age of 9 years and mean root completion is at 18.6 to 18.9 years of age.[21] Among the Israeli population, initial formation starts at 7 years of age and root completion begins to occur at 15 years of age.[23] The Nigerian population, on the other hand, showed initial third molar formation begins as early as 5 years of age to as late as 15 years of age.[25] Possible reasons for such differences can be attributed to racial variations as mentioned in the different studies of Harris, et al.[15] and Hashirm, et al.[16] Harris in 2001 stated that studies had suggested that African origin groups, with larger crowns and thicker enamel, spend less time in tooth formation than those of European descent.[15]

In this study, low percentage error among males and females indicate that CA and DA values of the two groups do not have significant difference within the population. This finding is consistent with other population groups such as the Israeli,[23] Nigerian,[25] Spanish,[24] South Indian,[20,21] and Thai[22] populations that reveal no significant difference between the CA and DA values.

Several scoring systems for third molar assessment are available. Though the study utilized the Modified Demirjian Scoring System, one of the most widely used, acceptable[21] and accurate scoring systems,[26] the goal is not to compare its accuracy with other scoring systems; it is suggested to also apply repetitive measurements and other techniques, and not adhere to a single age estimation technique. Since no scoring system can yet predict the actual chronologic age, it is important to apply other systems and techniques in order to make valuable conclusions in age estimation. Thus, exploring and testing other population based systems and techniques can be included in future research.

## CONCLUSIONS

In this study, the use of Modified Demirjian Scoring System in age estimation of the population presented a strong positive correlation between the CA and DA values. The study also revealed no significant difference between the CA and DA of the male and female population. All results of the study are consistent with most population based studies already conducted.

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## APPENDIX

### Modified Demirjian Scoring System

| | |
|---|---|
| **Stage o** | – Crypt outline visible. No calcification |
| **Stage A** | – Calcification of single occlusal points without fusion of different calcifications. |
| **Stage B** | – Fusion of mineralization points; the contour of the occlusal surface is recognizable. |
| **Stage C** | – Enamel formation has been completed at the occlusal surface and dentine formation has commenced. The pulp chamber is curved and no pulp horns are visible. |
| **Stage D** | – Crown formation has been completed to the level of enamelocemental junction. Root formation has commenced. The pulp horns are beginning to differentiate but the walls of the pulp chamber remain curved. |
| **Stage E** | – The root length remains shorter than the crown height. The walls of the pulp chamber are straight and the pulp horns have become more differentiated than in previous stage. In molars, the radicular bifurcation has commenced to calcify. |
| **Stage F** | – The walls of the pulp chamber now form an isosceles triangle and the root length is equal to or greater than the crown height. In molars the bifurcation has developed sufficiently to give the roots a distinct form. |
| **Stage G** | – The walls of the root canal are now parallel, but the apical end is partially open. In molars, only the distal root is rated. |
| **Stage H** | – The root apex is completely closed (distal root in molars). The periodontal membrane surrounding the root and apex is uniform in width throughout. |