RESEARCH PAPER

Validation of Cameriere's Method for Dental Age Estimation in Indian Children Aged 10–15 Years: A Cross-Sectional Radiographic Study

Dr. Shabna Fathima S[1]*, Dr. Sunila Thomas[2], Dr. Deena C Thomas[3], Dr. Shiana Jo[4], Dr. Abhilash R Krishnan[5], Dr. Alaka Subodh[6]

[1]Department of Oral Medicine and Radiology, PMS College of Dental Science and Research, Trivandrum, KUHS- affiliated
[2]Department of Oral Medicine and Radiology, PMS College of Dental Science and Research, Trivandrum, KUHS -affiliated
[3]Department of Oral Medicine and Radiology, Sri Sankara Dental College, DCI, KUHS-affiliated
[4]Department of Oral Medicine and Radiology, PMS College of Dental Science and Research, KUHS - affiliated
[5]Department of Oral Medicine and Radiology, Sri Sankara Dental College, DCI, KUHS-affiliated
[6]Department of Public Health Dentistry, Sri Sankara Dental College, DCI, KUHS - affiliated
Corresponding author: Dr Shabna Fathima S., shabnazim@gmail.com

ABSTRACT

Background: Cameriere's method represents a quantitative radiographic approach for dental age estimation in children, utilizing normalized measurements of open apices and tooth lengths from the seven permanent mandibular teeth visualized on panoramic radiographs.

Materials and Methods: This cross-sectional validation study analyzed digital panoramic radiographs from 50 children (21 males, 29 females) aged 10–15 years, sourced from routine clinical records. Root maturity was quantified by assessing the number of teeth (N_0) with complete apical closure (N_0) and normalized apical widths ($X_i = A_i/L_i$) for teeth 31–37 (left mandibular). Estimated dental age was derived using Cameriere's regression formula, with chronological age calculated from verified birth records. Analyses employed SPSS version 17.0 (SPSS Inc., Chicago, IL, USA); $P < 0.05$ denoted statistical significance.

Results: Cameriere's method systematically underestimated chronological age (mean residual: 1.0 ± 0.6 years). No significant sex difference emerged in mean residuals ($P = 0.126$). Strong positive correlations linked chronological and estimated ages overall ($r = 0.82$, $P < 0.001$) and by sex (females: $r = 0.895$; males: $r = 0.776$; both $P < 0.001$), confirming robust linear concordance.

Conclusions: Although systematic underestimation occurred across age groups, the method's high correlation and non-significant sex bias support its applicability for dental age estimation in this population, albeit with caution regarding predictive accuracy thresholds.

Clinical relevance: Quantitative assessment of open apices in the seven left permanent mandibular teeth via panoramic radiography offers a reliable, non-invasive tool for forensic age verification and clinical decision-making in children aged 10–15 years, enabling precise correlation of root development stages with chronological age through population-calibrated regression models.

Keywords: age estimation, Cameriere's method, Dental age

How to cite this article: Shabna Fathima S, Thomas S, Thomas DC, Jo S, Krishnan AR, Subodh A. Validation of Cameriere's Method for Dental Age Estimation in Indian Children Aged 10–15 Years: A Cross-Sectional Radiographic Study. Int J Drug Deliv Technol. 2026;16(6): 890-897. DOI: 10.25258/ijddt.16.6.129

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Age estimation represents a cornerstone of forensic odontology, enabling the identification of both living individuals and human remains.[1] This discipline is indispensable in forensic investigations, where it aids in profiling unknown cadavers, evaluating criminal culpability, and resolving civil disputes such as immigration status, adoption proceedings, and verification of legal thresholds for marriage or employment.[2] In mass disaster scenarios, age estimation contributes essential biological data to victim identification protocols, particularly when documentary evidence is unavailable or unreliable.[3]

Beyond medico-legal contexts, age assessment is pivotal in cases of child maltreatment, asylum seeker evaluation, age fabrication, and assessments of juvenile offenders or victims, as well as adaptability in foster care. Developmental variability among peers necessitates multifaceted evaluations encompassing somatic maturity, skeletal growth, sexual dimorphism, and dental ontogeny.[1] Unlike skeletal or somatic markers, which are highly susceptible to nutritional deficits, endocrine disruptions, and socioeconomic influences, dental development exhibits robust genetic determinism and relative resilience to extrinsic factors.[4] Consequently, dental radiography, especially panoramic imaging, serves as a technique-insensitive modality for age estimation, leveraging enamel-dentin formation and root maturation timelines that are minimally perturbed by environmental stressors.[5]

Despite these advantages, critical lacunae persist in the age estimation literature. Foremost is the paucity of population-specific normative data, as genetic admixture, ethnic diversity, and regional ecologies profoundly modulate developmental trajectories.[6] Methods validated in European cohorts, such as Cameriere's quantitative analysis of open dental apices, often yield suboptimal accuracy when extrapolated to non-Caucasian groups owing to these disparities.[7] Moreover, estimation precision deteriorates markedly in post-adolescent and adult populations, where error intervals expand due to completed apical closure and secondary dentin deposition.[8] The nascent concept of the biological age gap, discrepancies between chronological and physiological maturity, remains underexplored. Alongside the imperative for harmonized, non-invasive protocols applicable across global demographics.[9] Finally, methodological heterogeneity impedes synthesis of more data of different race and the establishment of gold-standard benchmarks.[10]

Addressing these voids, studies employing measurements of open apices in the permanent mandibular teeth using orthopantomography offer a reproducible, radiation-minimal approach, optimally suited for pediatric and adolescent cohorts of age 10–15 years. This methodology underpins regression formulae that correlate apical widths with chronological age, enhancing forensic utility in disputed birth records, orthodontic planning, and endocrinologic diagnostics. [1] Population-tailored validations refine predictive models, mitigating biases inherent in originator datasets like Cameriere's European sample.

The present investigation thus sought to juxtapose chronological age derived from verified records against estimates obtained via Cameriere's apical measurement protocol in mandibular teeth among 10 to 15-year-old children. Specific objectives include: (1) documenting chronological ages; (2) computing ages via Cameriere's regression equations; (3) quantifying discrepancies between chronological and estimated ages; and (4) evaluating bilateral symmetry by comparing left- versus right-side measurements.

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

This cross-sectional radiographic validation study was conducted retrospectively between August 2016 and July 2017 at the Department of Oral Medicine and Radiology, PMS College of Dental Sciences and Research, Kerala, India. Digital panoramic radiographs (orthopantomograms, OPGs) from 50 children (21 males, 29 females) aged 10–15 years were analyzed. Institutional ethics approval was secured prior to data collection (PMS/IEC/2015/22), and written informed consent was obtained from parents or legal guardians.

PARTICIPANTS

Eligible OPGs were sourced from treatment records of patients undergoing routine panoramic imaging. Participants were stratified by chronological age (in completed years) and sex, with no further age-group subdivisions specified.

INCLUSION CRITERIA:

The study included children aged 10–15 years, with OPGs demonstrating optimal visualisation of the apices of all permanent mandibular teeth (central incisor, lateral incisor, canine, first premolar, second premolar, first molar, second molar). Individuals who gave consent for study participation.

EXCLUSION CRITERIA:

OPGs with obscured apices due to superimposition of adjacent structures. History or radiographic evidence of craniofacial anomalies, dental malformations, jaw fractures, dental trauma, periapical pathology, or congenitally missing teeth. And, prior orthodontic intervention were all the exclusion criteria of the study.

SAMPLE SIZE CALCULATION

Sample size was estimated using the formula for comparing two means: where ($\alpha = 0.05$, two-tailed), (power = 80%), $\sigma = 0.72$ years (pooled standard deviation of age from prior studies), and $\Delta = 0.32$ years (anticipated mean difference in chronological vs. estimated age). This yielded $n \approx 42$, which was conservatively increased to 50 to account for potential exclusions.

RADIOGRAPHIC ASSESSMENT

Chronological age (CA) was calculated in decimal years from verified birth dates documented in municipal birth certificates. OPGs were processed using SIDEXIS software (integrated with the imaging unit) and calibrated for measurements. Effective radiation dose per OPG was 26 µSv (equivalent to ≈3.3 days of background exposure), qualifying as a non-invasive procedure.

Two calibrated observers independently evaluated dental maturity on calibrated images, with intra- and inter-observer reliability assessed (though not quantified here). The Cameriere method (2006) was applied to the seven left permanent mandibular teeth. For each tooth i (i=1 to 7)

Apical gap (A_i): Linear distance between inner edges of open apices (summed for multirooted molars 36 and 37).

Tooth length (L_i): Mesio-incisal (or mesio-buccal) to apical extent.

Normalized measure ($X_i = A_i / L_i$): Corrected for radiographic distortion.

VARIABLES DERIVED INCLUDED:

$s = \sum X_i$ (sum of normalized open apices).

N_0 = number of teeth with complete root development (apex fully closed).

g = sex indicator (1 for males, 0 for females).

Estimated dental age (DA) was computed via Cameriere's European regression equation:

$$DA = 8.971 + 0.375g + 1.631X_5 + 0.674N_0 - 1. \tag{XX}$$

where X_5 pertains to the second premolar (35). Right-side measurements were similarly obtained for bilateral symmetry evaluation (though primary analysis focused on left side).

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics (means, standard deviations) summarized CA, DA, and sex distribution. Agreement between CA and DA was evaluated via intraclass correlation coefficients (ICC, two-way mixed effects, absolute agreement). Paired t-tests assessed mean differences (CA – DA), with right- vs. left-side comparisons via independent t-tests or Wilcoxon signed-rank tests as appropriate. Statistical significance was set at $P < 0.05$. No adjustments for multiplicity were applied given the exploratory nature.

RESULTS

Fifty digital panoramic radiographs from children (21 males, 29 females) aged 10–15 years, collected between August 2016 and July 2017, satisfied inclusion criteria and underwent analysis (Table 1). Age distribution by sex and completed years is summarized in Table 1.

Table 1. Distribution of age and gender

Age	Male	Male	Female	Female	Total	Total
Age	Count	Percent	Count	Percent	Count	Percent
10–11	7	33.3	8	27.6	15	30.0
11–12	3	14.3	5	17.2	8	16.0
12–13	7	33.3	8	27.6	15	30.0
13–14	4	19.0	6	20.7	10	20.0
14–15	0	0.0	2	6.9	2	4.0
Total	21	100.0	29	100.0	50	100.0

Overall Age Estimation Accuracy

Mean chronological age (CA) was 12.2 ± 1.3 years, while mean estimated dental age (DA) by Cameriere's method was 11.2 ± 0.9 years, yielding a mean residual (CA – DA) of 1.0 ± 0.6 years [95% CI: 0.86–1.21]. This systematic underestimation of age was statistically significant (paired t-test, p< 0.001; Table 2).

Table 2. Comparison of mean of the difference between the chronological age and estimated age in the total sample

Total sample	CA	EA	Residual [EA–CA]	Residual [EA-CA]95%CI
N=50	12.2±1.3	11.2±0.9	1.0±0.6	0.86-1.21

Sex-Specific Differences

Males exhibited a mean CA of 12.0 ± 1.2 years and DA of 11.3 ± 1.0 years (residual: 0.8 ± 0.6 years). Females showed a mean CA of 12.2 ± 1.3 years and DA of 11.1 ± 0.9 years (residual: 1.1 ± 0.6 years). Independent t-test revealed no significant difference in mean residuals between sexes (p = 0.126; Table 3), with consistent underestimation across both groups.

Table 3. Comparison of mean of the difference between the chronological age and estimated age based on gender

Gender	CA	EA	EA–CA(Residual)	95%CIofResidual
Male	12±1.2	11.3±1	0.8±0.6	0.61-1.09
Females	12.2±1.3	11.1±0.9	1.1±0.6	0.89-1.34
P value of the residual of male and female = 0.126 [p < 0.05 - significant, <0.01 highly significant, >0.05-non-significant]	P value of the residual of male and female = 0.126 [p < 0.05 - significant, <0.01 highly significant, >0.05-non-significant]	P value of the residual of male and female = 0.126 [p < 0.05 - significant, <0.01 highly significant, >0.05-non-significant]	P value of the residual of male and female = 0.126 [p < 0.05 - significant, <0.01 highly significant, >0.05-non-significant]	P value of the residual of male and female = 0.126 [p < 0.05 - significant, <0.01 highly significant, >0.05-non-significant]

Age Group Stratification

Participants were stratified into five age bands (10–11, 12, 13, 14–15 years). Mean residuals increased progressively with advancing age, ranging from 0.5 ± 0.3 years (10–11 years) to 2.3 ± 0.8 years (14–15 years; Table 4). Discrepancies remained below 1 year in the youngest cohort (both sexes) but exceeded 1 year in older bands (12–15 years), irrespective of sex (Figure 1, Figure 2). This trend underscores diminishing accuracy at higher chronological ages.

Table 4. Comparison of mean difference between estimated age and Chronological age based on age

Age	CA	EA	EA–CA	95%CIof(EA-CA)
10–11	10.6±0.3	10.4±0.5	0.5±0.3	0.3-0.65
11–12	11.6±0.2	10.8±0.6	0.9±0.5	0.56-1.24
12–13	12.7±0.3	11.5±0.6	1.3±0.5	1-1.52
13–14	13.5±0.3	12.3±0.4	1.2±0.4	1-1.48
14–15	14.5±0.4	12.2±0.4	2.3±0.8	1.17-3.33

Correlation and Regression Analyses

Pearson's correlation coefficient demonstrated strong positive linear association between CA and DA for the total sample (r = 0.82, p < 0.001). Sex-stratified analyses confirmed robust correlations in females (r = 0.895, p < 0.001) and males (r = 0.776, p < 0.001), with coefficients >0.75 indicating excellent agreement (Figure 3, Figure 4). No substantial outliers were identified. Linear regression models for the total cohort, males, and females are depicted in Figures 5 and 6, affirming predictive utility despite systematic bias.

DISCUSSION

Age in the living assessment has gained relevance in various fields. The most common concerns are those related to child pornography, human trafficking, refugees, asylum seekers, and criminals and their victims. For adopting children from nations where birth registration is not available, an age assessment is also necessary. In competitive sports, age evaluation is another category that guarantees athletes are participating in an age-appropriate grouping for the sake of health and safety.[3] The process of estimating skeletal maturity involves analyzing the initial appearance and subsequent ossification of different bones. The degree of mineralization and the state of eruption of teeth can be used to determine dental maturity. Assessments of skeletal and dental maturity are the most widely utilized techniques for estimating age.[4] Dental and skeletal developmental ages play important role in optimal timing for treatment in orthodontic, orthopaedic or pediatric clinical practice.

Previous research in European populations revealed that the anterior dentition in males develops earlier than the anterior dentition in females, and the posterior deciduous dentition emerges earlier than the anterior.4 Since eruption is a gradual phenomenon that can be monitored based on x ray, it is readily applied than tooth eruption to evaluate dental maturation.5 Dental radiographs in terms of age estimation methods in living persons as they are convenient, simple, non-destructive which may be applied directly in living subjects.6Research have revealed that morphological measurements and formation stages of teeth can be reliably made in panoramic radiography with due consideration to variation in teeth size, magnification differences in radiographs and geometric unsharpness.7

The relationship between tooth mineralization and biological age has been assessed using a variety of techniques. These methods essentially include awarding codes based on predetermined scores and categorizing the stages of tooth mineralization visible in radiographs. Tooth development and hand-wrist bone is a useful maturity indication of the pubertal growth stage, even though the combined method somewhat underestimated age. When comparing the Demirjian and Cameriere approaches, Gupta S et al. (2023) 5found that the Cameriere approach is better than the Demirjian method of age estimation.

Chronological age comparison was based on measurements of the open apices of the permanent teeth with the dental age calculated using Cameriere's European formula. The 50 youngsters [21 boys and 29 girls] whose panoramic radiographs were chosen at random and met the inclusion and exclusion criteria had their chronological ages evaluated. Cameriere's European formula, which involves mandibular teeth, was used to estimate each patient's age. In this study, the minimum sample size of 42 was upsized to 50 and OPG of participants between 10 and 15 years were randomly selected as per the inclusion and exclusion criteria. Pattern of sample selection based on the studies by Cameriere et al.1, Rai and Anand10,11,12 Rivera et al.13 was adopted. Criteria for age in our study was from 10 to 15 years. In most studies the age range was 5 to 15 years.1,7,8 In a comparitive study by Timmins et al. (2011)14, comparing the various methods, the disadvantage of Cameriere method was that the teeth used for assessing age assumed maturity by 13.69 years in females and 14.06 in males. The researchers have revealed that Demirjian's method also assumed dental maturity by 16 years. Hence, it may be assumed that both these techniques may be best applied practically and accurately within the above-mentioned age groups. In our study, 5 age reference were identified from 10 years to 15 years. Due to the non-availability of the samples between 5 and 10 years the 5-10 year age reference were not included.

In Cameriere's original study the lower side of the mandible was evaluated for knowing the dental age of the individual. This was probably on the basis of the study done by the Cameriere's to know the person's dental age. This was most likely based on Demirjian's 1973 original study, which assessed dental maturity by evaluating and comparing all fourteen mandibular teeth with the 7 mandibular teeth. Researchers have used Cameriere's method to determine age after examining the mandibular teeth from the right side. Wolf et al. (2016) 6 had evaluated the mandible on the right side, and Jatti et al. (2013) 15 evaluated 7 teeth from either the left or right side of lower jaw provided the side had all seven teeth present. Both studies have neither specified their reason for selecting the right side for estimating dental age nor have they compared the values of right and left sides. However, they have obtained comparable results as with Cameriere's method.

Males and females in our study had mean chronological ages of 12±1.2 and 12.2±1.3 years, respectively. Cameriere's technique yielded an estimated age of 11.3 ± 1 for men and 1.1 ± 0.9 for

FIGURES

females. These findings demonstrated that Cameriere's approach understated the ages of the male and female participants in our study. Cameriere's formula has been used by a number of publications to understate age, and our investigation supports these findings. In their research with limited samples, Shreshta et al. (2014)16 and Pratyusha et al. (2017) 9 underestimated ages in females from 0.23 - 0.30 years and in males from 0.11 to 0.68 years. Several other authors have underestimated age using Cameriere's formula.1 All these studies indicate that as the population size increases, the range of underestimation reduces which in turn means that Cameriere's formula can be accurately applied for estimating age.23

However, Rivera et al.13 came to the conclusion that Cameriere's approach could precisely estimate Mexican children's ages with just a small underestimation and overestimation. However, Cameriere's technique overestimates age 0.02 years for girls and underestimates age by 0.09 years for boys, according to Galicet al.17.Fernandes et al 19Darıcı A 20Carelli J.21 Abuabara A22,23 evaluated Cameriere's method's accuracy among Brazilian children and discovered that it overestimates age in children aged 5 to 10 and underestimates age in children aged 5 to 11. Cameriere's reached reliable outcomes and could be applied for dental age estimation purposes.24,25,26

Small sample sizes for both evaluating the accuracy of the technique as well as for developing a region-specific formula. Future research should investigate the effects of the sample's regional background, gender, nutrition, and chronological age distribution on the accuracy and reliability of dental age assessment in Egyptian children, moreover, to evaluate the applicability of this specific formula on another sample size and to compare its reliability with other methods of age estimation.

CONCLUSION

In our research significant result was observed and actual age in the total population, and positive correlation was seen among participants. The mean difference in the residuals even though more in females than in males, was found to be statistically insignificant. In our study we observed that the present method underestimated age in all age groups. However, insignificant values shows that it can be used with much accuracy to estimate the dental age in our population and that panoramic radiograph may be used with sufficient accuracy to assess the age of a child, especially between 10 to 15 years. Further studies with larger samples are required to compare actual age and age estimated using Cameriere's method for both evaluating the accuracy of the technique as well as for developing a region-specific formula.

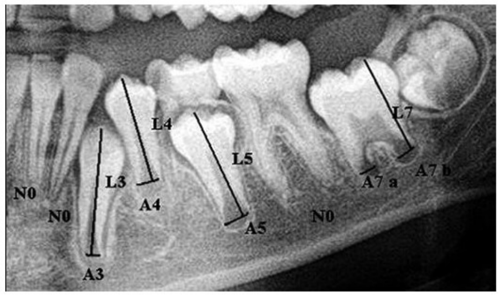

Figure Tooth measurement using Cameriere's method

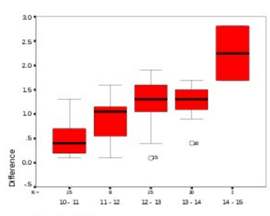

Figure Graph 1: Box plot for difference between estimated age and Chronological age based on age
Graph 2: Comparison of mean difference between estimated age and Chronological age based on age

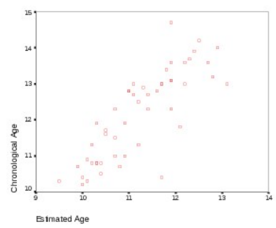

Figure r=0.82, p=0.000**

Graph 3: Scatter diagram for chronological age and estimated age for the total sample

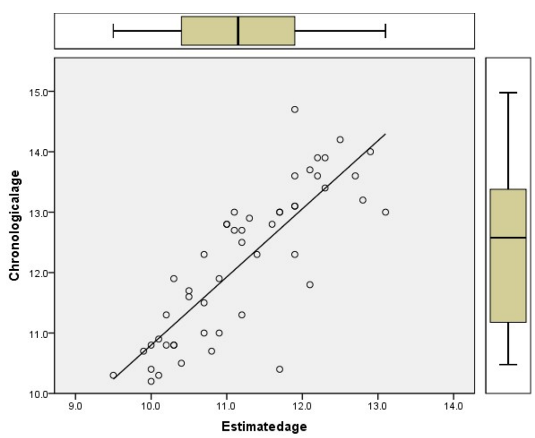

Figure Scatter plot with regression line for chronological age and estimated age for the total sample

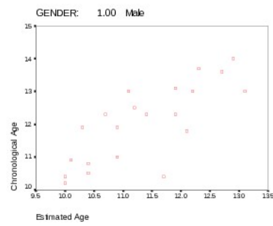

Figure r=0.776, p=0.000**
Graph 5: Scatter diagram for chronological age and estimated age for males

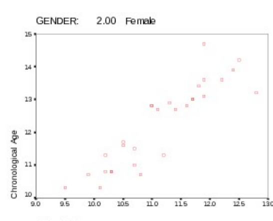

Figure r=0.895, p=0.000 ** Significance at 0.01 level**
Graph 6: Scatter diagram for chronological age and estimated age for females

REFERENCE

1. Cameriere R, Ferrante L, Cingolani M. Age estimation in children by measurement of open apices in teeth. Int J Legal Med. 2006; 120(1):49-52.

2. Galic I, Pacifici A, Carbone D, Pacifici L, Jeroncic A, Cameriere R. Age estimation by the Cameriere's normalized measurements (CNM) of the single permanent mandibular tooth on a panoramic radiograph. Leg Med. 2017; 26:65-72.

3. Cugati N, Kumaresan R, Srinivasan B, Karthikeyan P. Dental age estimation of growing children by measurement of open apices: A Malaysian formula. J Forensic Dent Sci 2015;7:227-31

4. Sharma P, Wadhwan V, Prakash R, Goel, Aggarwal P. Age estimation in children by measurement of open apices in teeth: a study in North Indian population. Australian J Forensic Sci. 2016; 48(5): 592-600

5. Gupta S, Verma AK, Patil R, Singh US, Kumar N, Bhattacharya S. Comparison of Demirjian and Cameriere methods and development of modified Cameriere and Demirjian formula more efficient for North Indian population. J Oral Maxillofac Pathol. 2023; 27(1):138-147.

6. Wolf TG, Briseño-Marroquín B, Callaway A, Patyna M, Müller VT, Willershausen I, et al. Dental age assessment in 6- to 14-year old German children: Comparison of Cameriere and Demirjian methods. BMC Oral Health. 2016; 16:120-30.

7. Javadinejad S, Sekhavati H, Ghafari R. A comparison of the accuracy of four age estimation methods based on panoramic radiography of developing teeth. J Dent Res Dent Clin Dent Prospects. 2015;9(2):72-80.

8. Cameriere R, De Luca S, Biagi R, Cingolani M, Farronato G, Ferrante L. Accuracy of three age estimation methods in children by measurements of developing teeth and carpals and epiphyses of the ulna and radius. J Forensic Sci. 2012; 57(5):1263-70.

9. Pratyusha K, Prasad MG, Radhakrishna AN, SaujanyaK, Raviteja NV, Chandrasekhar S. Applicability of Demirjian's Method and Modified Cameriere's Methods for Dental Age Assessment in Children. J Clin Diagn Res.2017;11(2):40-45.

10. Rai B, Anand SC. Age estimation in children from dental radiograph: A regression equation. Int J BiolAnthropol. 2007; 1(2):1-5.

11. EL BakaryAA, HammadSM, Ibrahim. Comparison between methods of dental age estimation among Egyptian children. Mansoura J Forensic Med Clin Toxicol.2009;17:75-86.

12. Pinchi V, Pradella F, Vitale G, Rugo D, Nieri M, Norelli GA. Comparison of the diagnostic accuracy, sensitivity and specificity of four odontological methods for age evaluation in Italian children at the age threshold of 14 years using ROC curves. Med Sci Law. 2016; 56(1):13-8.

13. Rivera M, De Luca S, Aguilar L, Palacio LA, Galic I, Cameriere R. Measurement of open apices in tooth roots in Colombian children as a tool for human identification in human and criminal proceedings. J Forensic Leg Med. 2017; 48:9-14.

14. Timmins K, Liversidge H, Farella M, Herbison P, Kieser J. The usefulness of dental and cervical maturation stages in New Zealand children for disaster victim identification. Forensic Sci Med Pathol. 2012; 8(2):101-8.

15. Jatti D, Kantaraj Y, Nagaraju R, Janardhan S, Nataraj S. Age estimation by measuring open apice of lower erupted teeth in 12–16 years old by radiographic evaluation. J Forensic Leg Med. 2013;20(5):430-4.

16. Shrestha et al. Measurement of open apices in teeth for estimation of age in children. Health Renaissance 2014; 12(1): 33-3

17. Galic I, Vodanovic M, Cameriere R, Nakas E, Galic E, Selimovic E, Brkic H. Accuracy of Cameriere, Haavikko ,and Willems radiographic methods on age estimation on Bosnian–Herzegovian children age groups 6–13. Int J Legal Med. 2011;125(2):315-21.

18. Guo YC, Yan CX, Lin XW, Zhou H, Li JP, Pan F et al. The influence of impaction to the third molar mineralization in northwestern Chinese population. Int J Legal Med 2014; 128:659–665

19. Fernandes MM, Tinoco RL, de Braganca DP, de Lima SH, Junior LF, Junior ED. Age estimation by measurements of developing teeth: accuracy of Cameriere'smethod on a Brazilian sample. J Forensic Sci.2011; 56(6):1616-9.

20. Darıcı A, Ölmez MS, Güngör HC, Rajavaara P, Sipola A, Anttonen V, Päkkilä J. Comparison of accuracy of different dental age estimation methods in Finnish and Turkish populations. Acta odontol Scand. 2024 ;22;83:643-652.

21. Carelli J, da Silva GS, Gomes MV, Vilalba T, Baratto-Filho F, Armando Brancher J, Beisel-Memmert S, Kirschneck C, Lopes CMCF, Moro A, Küchler EC. Demirjian's and Cameriere's Methods for the Assessment of Dental Age Estimation in Children from a Southern Brazilian City. Diagnostics (Basel). 2024 Jul 13;14(14):1513.

22. Abuabara, A., Antunes, L., Antunes, L. et al. Age estimation using dental radiography in the Brazilian population: a systematic review and meta-analysis. Egypt J Forensic Sci 2025;56(2):345-350.

23. PhulariRashmi GS, Dave EJ. Evolution of dental age estimation methods in adults over the years from occlusal wear to more sophisticated recent techniques. Egypt J Forensic Sci 2021;11:36.

24. Rezende Machado AL, Borges BS, Cameriere R, Palhares Machado CE, Alves da Silva RE. Evaluation of Cameriere and Willems age estimation methods in panoramic radiographs of Brazilian children. J Forensic Odontostomatol. 2020 Dec 30;38(3):8-15.

25. Melo, M., Ata-Ali, F., Ata-Ali, J. et al. Demirjian and Cameriere methods for age estimation in a Spanish sample of 1386 living subjects. Sci Rep 2022;2(3): 2838 45

26. Shen, S., Liu, Z., Wang, J. et al. Machine learning assisted Cameriere method for dental age estimation. BMC Oral Health 2021; 23(1):25-40.