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Comparison of the London Atlas Method of Age Estimation with the Chronological Age in a South Kerala Population

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Abstract

Background and Aim: The London Atlas is a recently introduced method of age estimation using orthopantomographs (OPGs), which has not been tested in the Kerala population. Thus, the present study was carried out to assess and compare the chronological age of the participants with the estimated age using the London Atlas method.

Materials and Methods: A retrospective cross-sectional study was conducted to evaluate the London Atlas method for age estimation using OPGs of 220 healthy individuals (60.5% females and 39.5% males) between 5 to 23.99 years collected from the archives. The chronological age of the participants was calculated using their date of birth. Data were analyzed by paired t-test and Pearson's correlation coefficient (alpha=0.05). The intra-examiner reliability was analyzed using the Cohen's kappa.

Results: A statistically significant difference existed between the chronological age and the age estimated using the London Atlas method (t-value=-8.301, P<0.05). A positive statistically significant correlation was found between the estimated age using the London Atlas method and the chronological age in all age groups (Pearson's correlation coefficient of 0.989 in males and 0.985 in females, P<0.05). The goodness of fit evaluation of the London Atlas method for prediction of actual age indicated that the model can fit with R2 value of 0.975.

Conclusion: The London Atlas method showed a strong positive correlation with actual chronological age while at the same time a statistically significant difference existed between the actual age and estimated age. There was no difference in age estimation between the two genders.

Keywords: Age Determination by Teeth; Forensic Dentistry; Radiography, Panoramic

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Introduction

Estimation of dental age is required in certain situations like when the date of birth is unknown or disputed, and as an aid in identifying unknown human skeletal remnants in scenes of mass disasters, in criminal cases when the age of an

accused individual is in doubt whether he/she has reached the age of maturity to charge the criminal responsibility and in civil procedures like in adoption cases when the person lacks valid documents for age determination [1,2]. Radiography can be used in dental age assessment, and has certain advantages over other methods such as its non-invasive; also, radiographs can be obtained from both the living as well as the dead [2].

AlQahtani et al. [3] developed the London Atlas method for age estimation. They used both tooth formation and eruption pattern of teeth in the alveolar bone in individuals between 28 weeks in-utero to 23 years. The authors used collections of human skeletal remains obtained from the Paleontology Department, Natural History Museum, London, and the orthopantomograms (OPGs) from the Odontological Collection at the Royal College of Surgeons of England for this purpose. The London Atlas method was first evaluated in individuals of British and Bangladeshi ethnicity. Investigations revealed that it was more precise than the Schour, Massler, and Ubelaker methods [4], and it was also more accurate than the Demirjian's method [5]. With the London Atlas's potential for higher accuracy, a software version of the Atlas was developed, enabling rapid age estimation [3].

Only a few studies evaluated the accuracy of this method especially in the Indian population and concluded it is as an accurate and easy to use method compared with other radiographic methods of age estimation [5,6]. The accuracy of the London Atlas was evaluated in India by two studies only which were conducted on the North Indian population [5,6]. To the best of the authors' knowledge, no study has been conducted on the South Indian population including the state of Kerala. In India, there is still uncertainty about the best method to be used for age estimation. The invasive methods of age estimation are not useful in many scenarios. Complex methods are not easy to use, and a universal method is lacking. Evaluation of any new method in the Indian context makes an immense contribution to both the forensic science and the civil disciplines. The present study evaluated dental age estimation of individuals from a South Indian population using the London Atlas method in comparison with their chronological age to find the accuracy of this method.

Materials and Methods

A retrospective cross-sectional study was conducted on the OPGs of 220 dentate individuals, collected from the archives of the Department of Oral Medicine and Radiology, Azeezia College of Dental Sciences and Research, Kerala during the period of 2021-2022. Participants with any systemic disease affecting tooth development, oro-dental pathologies, obviously carious teeth, retained primary teeth, root stumps, impacted teeth, root resorption of primary teeth caused by teeth that are not their successors, history of orthodontic treatment, or extraction of teeth were excluded from the study. Good-quality OPGs of individuals between 5 years to 24 years visualizing all teeth were selected. The OPGs had been taken with NewTom GiANO high-resolution OPG machine (Cefla S.C.Via Selice Prov.Le/A-40026 Imola BO, Italy). Institutional ethics committee approval was obtained prior to the study onset (AEC/REV/2022/29).

The total sample size was calculated according to a previous study [1] assuming the standard deviation of difference in estimated and actual age to be 2.27, effect size of 0.3, 5% allowable error, and 95% confidence level; the sample size was calculated to be 220.

All OPGs were collected with the date of birth and the date radiographs were taken in date/month/year format. The clinical case

history was also used to evaluate the exclusion criteria. The chronological age of each individual was calculated and tabulated by subtracting the date on which the OPG was taken from the date of birth. The name and date of birth of the participants on the OPGs were blinded before examination by a co-investigator and then the OPGs were handed over to the principal investigator without any other information. The principal investigator assessed the dental age from the OPGs while being blinded to the chronological age. The age estimation was carried out under natural light, by viewing the digital OPGs using an image viewer software (Photos from Microsoft Corporation Version 2024.11070.31001.0) in a laptop (Acer Aspire 315-23 DESKTOP-3C14O1L, India).

The OPGs were examined to assess the developmental stage and alveolar eruption pattern of the deciduous and permanent teeth in the right side of both the maxilla and mandible. Subsequently, the dental age of the individuals was calculated by using the free London Atlas Software Application version 2.0 2020 (Country of origin United Kingdom available at http://www.atlas.dentistry.qmul.ac.uk). The table in the software app was filled by observing specific figures of the development stage and level of alveolar eruption of the teeth in the Atlas and matching and comparing them with the OPGs of each participant; the dental age calculator feature automatically displayed the dental age (Figures 1 and 2).

The intra-examiner reliability was evaluated by re-analyzing 10% of the OPGs randomly selected 2 weeks after the initial assessment following the same protocol used for age estimation. The Cohen's kappa was used to evaluate the intra-examiner reliability. The kappa value was found to be 0.900 indicating an 'almost perfect agreement' [7]. SPSS version 29.0 (IBM Corp. Released 2023. IBM SPSS Statistics for Windows, Armonk, NY, USA) was used for statistical analysis. Descriptive data were analyzed and reported as mean and standard deviation. Statistical tests including the paired t-test, and Pearson's correlation coefficient were used for data analysis. For all the tests, the significance level was considered less than 0.05.

Figure 1. Orthopantomograph of a participant used for age estimation

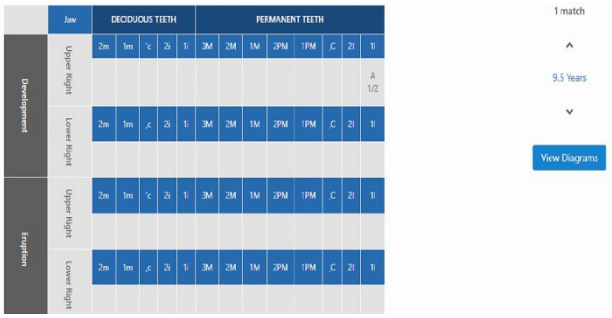

Figure 2. London Atlas software interface displaying the estimated age

Results

The total number of OPGs analyzed was 220. Among them, 133 (60.5%) belonged to females and 87 (39.5%) belonged to males. The age and gender-wise distribution of the study participants are presented in Table 1. The mean chronological age of the individuals was found to be 15.06 years with a standard deviation of 4.92 years. The mean estimated age was found to be 15.52 years with a standard deviation of 4.96 years. The chronological age of the participants ranged from 5.00 to 23.70 years, and the estimated age ranged from 5.00 to 23.50 years (Table 2). Paired t-test was carried out to evaluate the difference between the mean values of chronological age and estimated age using the London Atlas method. A statistically significant

difference was found between the chronological age and estimated age using the London Atlas method (Table 3).

Table 1. Age- and gender-wise distribution of the study samples

Age (years)	Gender		Total
	Females	Males	
5.00-5.99	3	4	7
6.00-6.99	3	4	7
7.00-7.99	3	2	5
8.00-8.99	3	7	10
9.00-9.99	5	5	10
10.00-10.99	3	5	8
11.00-11.99	4	1	5
12.00-12.99	7	7	14
13.00-13.99	9	9	18
14.00-14.99	19	5	24
15.00-15.99	12	2	14
16.00-16.99	12	1	13
17.00-17.99	7	6	13
18.00-18.99	11	4	15
19.00-19.99	5	8	13
20.00-20.99	7	6	13
21.00-21.99	7	5	12
22.00-22.99	8	2	10
23.00-23.99	5	4	9
Total	133	87	220

Table 2. Measures of central dispersion for the chronological and estimated age (n=220)

Variable	Minimum	Maximum	Mean	Std. Deviation
Chronological age	5.0	23.70	15.0673	4.92845
Estimated age using the London Atlas method	5.0	23.5	15.5218	4.96827

Table 3. Comparison of the mean values of chronological age and age estimated using the London Atlas method by paired t-test

Variable	Mean value ± SD	t-value	p value
Chronological age	15.067 ±4.92845	-8.301	0.00
Estimated age using London atlas	15.5218±4.96827		0.00

SD: Standard deviation

The Pearson's correlation test was done to assess the correlation between the estimated age (x-axis) by the London Atlas method and the chronological age (y-axis). A statistically significant positive correlation existed between the two while considering the overall samples (correlation coefficient= 0.987) (Figure 3).

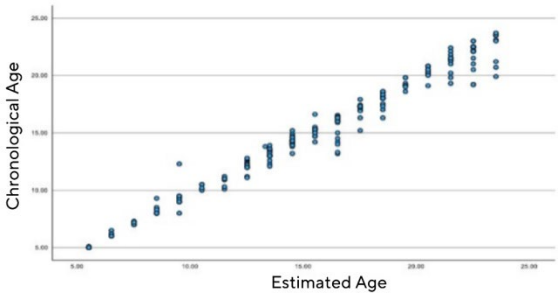

Figure 3. Pearson's correlation analysis for the correlation between the estimated age and the chronological age

The participants were divided into four age groups of 5.00-9.99 years, 10.00-14.99 years, 15.00-19.99 years, and 20.00-23.99 years, and the correlation of the estimated age and the chronological age was calculated using the Pearson's correlation test. The abovementioned age groups showed a correlation coefficient of 0.979, 0.840, 0.892, and 1.761, respectively. A statistically significant positive correlation existed between the estimated age using the London Atlas method and chronological age in all age groups (Table 4). The Pearson's correlation test was also carried out between the two genders and found a correlation coefficient of 0.989 in males and 0.985 in females. It was found that both genders showed a positive correlation, which was statistically significant (Table 5).

Table 4. Age group-wise Pearson's correlation analysis between the estimated age and chronological age

Age group (years)	Number	Pearson's correlation coefficient	P value
5.00-9.99	39	0.979	0.00
10-15.99	69	0.840	0.00
16-20.99	68	0.892	0.00
21-23.99	44	1.761	0.00

Table 5. Gender-wise Pearson's correlation analysis between the estimated age and chronological age

Gender	Number	Pearson's correlation coefficient	P value
Males	87	0.989	0.00
Females	123	0.985	0.00

Linear regression analysis was performed to analyze the goodness of fit of the estimated age by the London Atlas method to predict the chronological age of an individual, and it was found that the model can fit with R2 value of 0.975.

Discussion

Age estimation is considered a basic competency in forensic odontology, which is useful in scenarios where legal documents are unavailable for age determination or there is a legal dispute over a person's age [8]. Al Qahatani et al. [3] developed the London Atlas method for age estimation using OPGs by evaluating the stages of tooth development and alveolar eruption pattern of teeth up to the age of 23.99 years [4]. If an OPG is available, it can be compared with the London Atlas and one can estimate the age up to 23.99 years.

The literature search revealed only two studies carried out in the Indian population evaluating the London Atlas method done by Sharma and Wadhwan[6] in 2020 and Chowdhry et al. [5] in 2023. Both of these studies evaluated the OPGs of individuals from 5 years and 6 years to 15.99 years respectively, while the present study assessed the age from 5 years to 23.99 years, similar to Ishwarkumar et al [9]. Chowdhry et al. [5] compared the London Atlas method with Demirjian's method using 100 OPGs while Sharma and Wadhwan [6], compared the London Atlas with Cameriere's method using 335 OPGs. Both studies reported almost equal gender distribution. In contrast, the present study had an unequal gender distribution similar to Pavlovic et al. [10] (2017) with more samples belonging to females.

Ghafari et al [11], McCole et al. [2], Namwong and Mânica [12] and Sharma and Wadhwan [6] reported no statistically significant difference between the chronological age and the age estimated using the London Atlas method, while the present study reported an over estimation of age compared to the actual age in the male gender. Pavlovic et al. [10] reported an overestimation of age by one month in the whole samples while Sousa et al. [1] reported an overestimation of age in the female gender in their samples. Ismail et al. [13] reported an underestimation of age for the 10-year-old and 15-year-old age groups and an overestimation in the 5-year-old age group in their study. Chowdhry et al. [5] and Namwong and Mânica [12] also reported under- and overestimation in different age groups in their studies. Although there was an overestimation of age in the male gender in the present study, there was a strong linear correlation between the chronological age and age estimated by the London Atlas method similar to the study by Ghafari et al. [11]. Chowdhry et al. [5] also concluded that the London Atlas was more accurate than the Demirjian's method.

The present study revealed excellent intra-observer reliability comparable with the studies by McCole et al. [2] and Namwong and Mânica [12]. The London Atlas method is a simple, non-invasive and fast method of age estimation. The availability of a free online software app in 22 different languages makes it more user-friendly and popular [4,14]. It can evaluate age from 28 weeks in-utero; there are only a few methods that can estimate age, starting from the intra-uterine period [3].

Most previous studies found no statistically significant difference between the age estimated by the London Atlas method and the actual chronological age of the participants [2,6,11,12].

However, the present study reported that even though a strong positive correlation existed between the chronological age and the estimated age, there was a statistically significant difference between the estimated age and chronological age. The London Atlas method has an inherent shortcoming in estimating the age. It can only determine age with a precision of one year. For example, if the London Atlas estimates one person's age as 6.50 years, the actual age can vary from 6.00 years to 6.99 years. This method cannot predict age more precisely.

Even though the current study did not report any difference in age estimation between the two genders, Pavlovic et al. [10], Ismail et al. [13] and Sousa et al. [1] reported that sexual dimorphism can affect age estimation and suggested a separate Atlas for males and females. Santos et al. [15] reported satisfactory results with the London Atlas method in 8 to 19-year-old age group in a Russian population while they reported errors and bias in the 20- to 23-year-old age group [15]. Variations in the results are probably due to inclusion of third molars for age estimation in this group. Third molars show variations in their development and morphology, which can affect the precision of the London Atlas method in age groups where the third molar is also considered in the decision-making. It is to consider that, even though the dental method of age estimation is considered a precise method, there still can be variations that may affect age estimation. Thus, the difference in estimated age and actual chronological age may not be a flaw of the London Atlas method. The environment can also influence the development of teeth [12]. There are only a few studies available in the scientific literature regarding the accuracy of this newer method especially in the Indian context. The population in India is large, vast, and, diverse requiring more research on this method.

One limitation of the present study was that the samples were selected from a hospital setting. Also, the samples were not equally distributed among the two genders. Future studies may compare the right and left side teeth. Also, inter-observer variability should be analyzed in future studies. More studies on larger populations and different ethnic groups are required since growth and development considerably vary in different populations.

Conclusion

Based on the results of the current study, the following conclusions can be made:

1) The London Atlas method showed a strong positive correlation with actual chronological age.

2) A statistically significant difference existed between the chronological age and the estimated age.

3) No difference existed in estimated age between males and females.

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