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Application of the London Atlas of Tooth Development and Eruption in Panoramic Xrays for the Age Estimation

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ABSTRACT

Background: The age estimation of the individual by the forensic experts ascertains the chronological age of an individual. The possibility that the person being examined may be younger or older than a certain age threshold makes this process crucial, as it will establish whether or not the person is an adult under the law. The aim of this study was to test the applicability of the London Atlas of tooth development and eruption in Nepalese subset population.

Methods: The London Atlas for age estimation was tested in 350 digital panoramic radiographs from the patients between four and twenty-four years visiting Tribhuvan University Teaching Hospital, Institute of Medicine, Nepal.

Results: The mean values of the estimated age were higher in both the sexes, which was statistically not significant. Both the sexes showed an excellent positive correlation, and was significant with a p value of <0.001. The age estimation upto 10 years group classification was nearly accurate with less than 1 and 2.5 years variation in males and females respectively. The accuracy was good in 16-18 years group with maximum deviation of ± 2.5 years. The accuracy was poor in more than 18 years group, as the variability was more than 5 years.

Conclusions: The London Atlas method was best suited for less than 18 years of age and was not very accurate in the age group of 13-14 and 14-15 years where most of the polymorphisms were noted.

Keywords: Dental age estimation; London Atlas; Nepalese population.

INTRODUCTION

One of the most important aspects of medical-legal casework is age estimation.[1] When a birth date is uncertain, unreliable, or non-existent, judicial authorities order a chronological age estimation test.[2] Knowing the right age in a criminal case is crucial for evaluating whether the defendant has reached the age of criminal responsibility or the legal age of majority.[3, 4]

Dental age estimation is widely used. It is considered as reliable indicators of chronological age.[5,6] As, both the developmental and eruption of teeth age estimation methods are reported to exhibits low variation.[7-9]

Dental age estimation is important in Nepalese population due to increased child labor and child abuse cases in Nepal. If the reliability of the London atlas can be established in the Nepalese population, this method can be used frequently for age assessment of children and adolescents for medicolegal purposes. Thus, this study aimed to test the applicability of the London atlas of tooth development and eruption in Nepalese population.

METHODS

This cross-sectional study was conducted on 350 Orthopantomographs (OPGs) selected by non-probability sampling from the patient's upto 24 years of age visiting the Tribhuwan University Teaching Hospital for various dental treatments. This study was conducted from January 2020 to January 2022. Ethical approval was

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obtained from Institutional Review Committee, Institute of Medicine before conducting the study [Ref. 334(6-11-E)[2] 074/075].

The OPGs of patients that were of good quality with all teeth in focus without the history of trauma, severe debilitating diseases, bilateral mandibular third molars impaction and hypodontia were included in the study. The OPGs of patients with teeth associated with cyst or tumours, distorted X-rays were excluded from the study.

The dates of birth and sex of the participants were recorded by one investigator, while the second investigator, who was blinded, scored the developmental stages of the teeth from OPGs. Only right side of the X-ray was used for the age estimation. As studies have indicated there is no statistically significant difference between the two sides.[2] Moreover, the examiner can use teeth from any side depending on clarity of the radiograph.[10] The digital images of the radiographs were evaluated without knowing the age of the individuals beforehand. The radiographs were compared to the different illustrations provided in the London atlas. Each OPG was assigned a unique number, and the dental age for the radiograph was calculated according to the London atlas.

Data was compiled in a Microsoft Excel ® sheet and the estimated dental age was compared to the chronological age using paired t test and Pearson's correlation coefficient. Bland Altman Plots were used to visualize the deviation in the prediction of actual and estimated age. Two observers did the age estimation and the values were tested for agreement using intraclass correlation analysis. All the analysis was done using SPSS V.20.0 (IBM, Chicago). A p-value of 0.05 was considered as statistically significant at a confidence interval of 95%.

RESULTS

The mean values of the estimated and the chronological age were compared using paired t test (Table 1). The results showed that the mean values of the estimated age were higher both in males and females but statistically not significant with a p value of 0.055.

The chronological age was correlated with the estimated age (Table 2 and Figure 1) using pearsons correlation. An excellent positive correlation (r value >0.9), with a p value of <0.001 was seen in the total population as well as in each sex individually.

Table 2. Correlation of the chronological age with the estimated age.

	Correlation between the parameters	N	Correlation (r)	P VALUE
Female	Estimated age & chronological age	212	0.962	**<0.001**
Male	Estimated age & chronological age	136	0.945	**<0.001**
Total	Estimated age & chronological age	348	0.955	**<0.001**

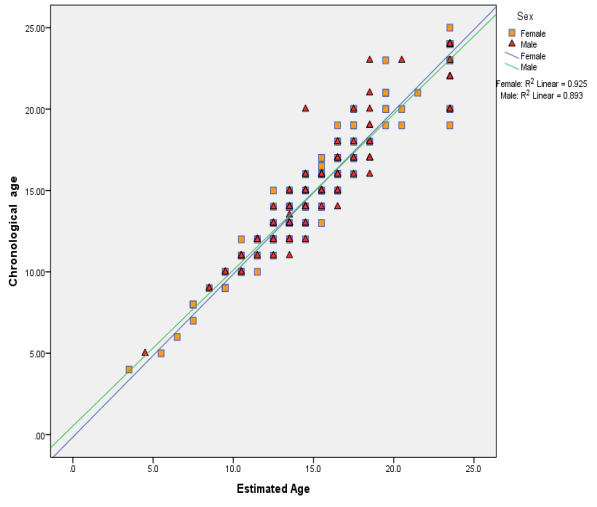

Figure 1. Linear correlation of the chronological age with the estimated age.

Table 1. Paired t test to compare of the mean values of the estimated and the chronological age.

		N	Mean ± SD	Mean difference ± SD	t	P value
Female	Estimated Age	212	15.19±3.79	0.13±1.08	1.68	0.094
	Chronological age	212	15.06±3.95			
Male	Estimated Age	136	15.33±3.7	0.11±1.24	1.01	0.316
	Chronological age	136	15.22±3.75			
Total	Estimated Age	348	15.24±3.75	0.12±1.14	1.92	0.055
	Chronological age	348	15.13±3.87			

Association of errors in estimation of age in both the males and females were tabulated (Table 3). Estimation within a range of 1 year was seen in 245/348 cases (70.4%) indicating efficiency of London atlas method of age estimation. The over estimation of >2 years was seen in 3.2% of the total sample (2.4% females and 4.4% males). The overestimation of 1-2 years was seen in 14.6% females and 15.4% males and 14.9% of the total sample. Under estimation of age was more prevalent in females than in males. The underestimation 1-2 years was seen in 9.9% females 5.9% males (8.3% of the total sample). The underestimation >2 years was seen in 2.4% females 3.7% males and 2.9% of the total sample. The Pearson Chi Square test showed value of 7.499 and p value of 0.277, which was statistically non-significant.

Table 3. Association of errors in estimation of age in both the males and females.

Deviation in Estimation	Female	Male	Total
Overestimation >2 years	5.0 (2.4%)	6.0(4.4%)	11(3.2%)
Overestimation 1-2 years	31(14.6%)	21(15.4%)	52(14.9%)
Overestimation <1 years	84 (39.6%)	43(31.6%)	127(36.5%)
Underestimation <1 years	66 (31.1%)	52(38.2%)	118 (33.9%)
Underestimation 1-2 years	21 (9.9%)	8 (5.9%)	29(8.3%)
Underestimation >2 years	5 (2.4%)	5(3.7%)	10(2.9%)
Total	212 (100%)	136 (100%)	348 (100%)

The scatter plot shows the deviation in prediction between the actual age and the estimated age in males and females in different age groups (Figure 2). Under 10 year age group showed predominantly <1-year variation in males and <2.5 year variation in females. The accuracy was good in the 16-18 years group with maximum deviation of ± 2.5 years. The accuracy was poor in >18 years of age with the variability of more than 5 years. This indicates the London Atlas method is best suited for <18 years of age and is not very accurate in the age group of 14-15 years where most of the polymorphisms was noted shown in Figure 2.

The inter-observer agreement was tested using two-way random effect in 17% of the sample after 15 days. The study showed an excellent inter-observer agreement. The intraclass agreement (ICC) was 92 % with ICC variable 0.92 and p value of <0.001.

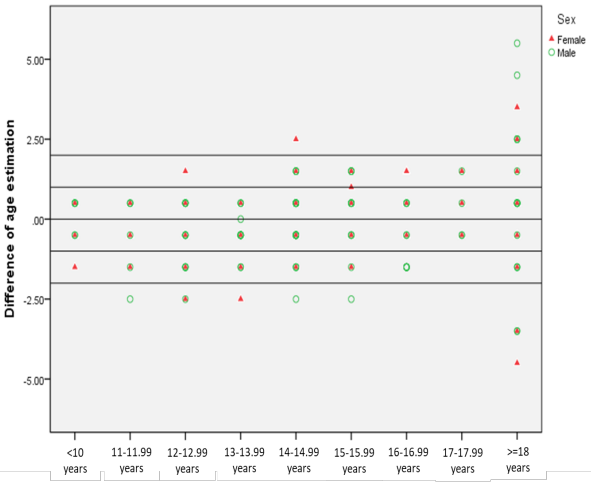

Figure 2.The scatter plot to demonstrate deviation of the estimated age from the chronological age.

DISCUSSION

The radiological methods for age assessment are divided into two categories:[9,11] scoring methods, in which the developmental stages of individual teeth are identified and scored, which is then used in a linear regression formula to produce an age estimate that is compared to published standards.[12] The second method is to do a direct comparison with dental age diagrams from a chart or atlas.[13,14] AlQahtani, Hector, and Liversidge (2010)[15] developed a comprehensive atlas for age estimation, known as London Atlas using both tooth formation and eruption in relation to alveolar bone.[15] London Atlas uses a clear diagram with a textual description of each step of tooth development and eruption stages as seen in OPGs.[15] Thus, the study samples were examined by direct observation and comparison of the stages of tooth formation in panoramic radiographs with the stages described in the London Atlas and its illustrations.

The increased child labor and child abuse cases in Nepal[16,17] madates adoption of a realiable easy method of age estimation. Despite the widespread use of dental development schemas to assess maturity and estimate dental age, there is little evidence that they are accurate when applied to diverse ethnic groups. Thus, testing of this method was done to adopt it for age assessment of children and adolescents for medicolegal purposes in Nepal.

The mean values of the estimated age was higher than chronological age but statistically non significant in both the sexes. This is in accordance with the other studies; McCloe et al. (+0.35 years),[18] Sharma and Wadhwan

(+0.03 years), [5] Ghafari et al. (+0.57 years). [19] However, Pavlović et al.[20] studies showed the estimated age to be higher than chronological age in males compared to females but statistically non significant. This variation in the mean values could be attributed to ethinic and gender variation of the study sample along with the accuracy of the age estimation technique used in various studies.

The Pearson's correlation coefficients suggested strong linear correlations between the chronological and the estimated age in the present study similar to Sezer and Berka [21] and Ghafari et al.[19]

The present study mostly showed deviation from the chronological age by ± 1 year similar to other studies.[20, 22] However, significant number of individuals showed variation of more than 1 year similar to Sezer and Çarıkçıoğlu who reported overestimation of the chronological age by 0.09 years in Turkish children.[21] Similarly, Namwong and Manica[23] reported underestimation of 1.3 years in <10 years group in Indonesian children similar to the present study. McCloe[18] reported a significant bias towards overestimation in Hispanic children by 3%. The greatest amount of bias and absolute error was seen in 13-14 years in Hispanic children[18] similar to the present study. This could be related to the fact that there are fewer teeth expressing differences in maturity at 12 years of age and higher, therefore a single tooth's variation may not have a greater impact on determining an age. Ismail et al., [24] reported underestimation in the 10 years group. While 22.5-23.5 years showed underestimation similar to our study while Sharma & Wadhwan [5] reported, non-significant underestimation and overestimation in all age groups, highlighting the accuracy of London Atlas.

Precision or reliability refers to the degree to which additional measurements or calculations produce the same or similar results as the first. A more accurate or valid procedure will result in a lower disparity between dental and chronological age, as well as a smaller bias.[25, 26] In the study by Ghafari et al.[19] London Atlas estimated the chronological age of 77.6% participants accurately (with a deviation of ± 1 year). [19] Alshihri et al. [22] reported the estimated age of 65.5% of the subjects to be accurate (with a deviation of ± 1 year), underestimation of 19% of the participants and overestimation of 15.5% of the studied individuals with a deviation greater than 1 year.[22] Similarly, Alqahtani et al.[15] reported the accuracy of 52.8%, overestimation in 23.12 % and underestimation in 24.0% of their study sample. Similarly, McCloe[18] reported accuracy of 49%, overestimation of 38%, and underestimation in 13% in Hispanic children. The variation in the accuracy may be attributed to ethnic variation of the study sample.

Analysis by gender showed interesting results. There were considerable disparities between the sexes similar to other studies.[15, 20, 22] However, McCloe[18] reported no significant difference in dental age estimation accuracy between males and females. In the present study overestimation was seen more in females than in males similar to other studies.[2] Females complete their permanent dentition earlier than males in general as reported by previous research.[27,28] This could have a direct influence on the disparity between the sexes. However, the finding of the present study contradicts the study by Pavlovic et al.[20] and Alqahtani et al.[15] which showed overestimation only in males but underestimation in females. Nevertheless some studies have reported that London atlas estimates age closer to the chronological age in females.[20] As a result, even if the London Atlas technique is not yet predominantly separated by sex in its initial graphics, analysis should be performed separately for better results.

Sousa et al.[2] reported polymorphism in the age group of >18 years in Brazilian population similar to our study. The greatest disparity in our study was seen where only the third molar was still developing, reflecting the tooth's variability. The age estimation beyond 16.5 years is based on a single tooth, which has high variability in angulation, onset of development, and morphology within the same population fraction leading to polymorphism.

The study showed an excellent intra-observer reliability simialr to other studies.[14] The intraclass coefficient in our study showed almost perfect agreement to Alqahtani (0.879),[15] and Sharma and Wadhwan (0.997). [5] The higher intraclass coefficient seen in various studies indicate the atlas' simplicity of use and reliability on age estimation. The assessment of inter-observer reliability was not included in our study, so comparison couldn't be done in this case.

The sample size of the age groups studied varied. As a result, standard deviations for each age range group with fewer radiographs could not be calculated. Also, the ethinic variation amongst the Nepali population was not evaluated.

London atlas should be tested separately for each population for accuracy and population specific formula needs to be developed.

Sex based analysis should be performed separately for better results.

The polymorphism was noted in 13-14 years and 14-15 years due to lack of distint variation in the diagramatic representation of London Atlas of tooth development and eruption in these age range. Thus, the Atlas should be improved in this area.

CONCLUSIONS

The results obtained from the present study based on Nepalese population concludes that the London Atlas method was best suited for <18 years of age and was not very accurate in the age group of 14-15 years where most of the polymorphisms was noted.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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