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Demirjian's Eight Teeth Method for Dental age Estimation in Nepalese Population

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ABSTRACT

Background: Demirjian's method is widely used method for dental age estimation. This study was conducted with objectives of applying Demirjian's 8 teeth method to estimate age in Nepalese Population and to determine Nepal-specific formulas.

Methods: We had used the Orthopantomographs of Nepalese people of age above five and below 23 years. The radiographs were compared to the 'Tooth Development Chart' and each tooth studied was assigned with any one of the 10 developmental stages using Demirijian's 8 teeth method and total maturity scores determined. Formulas were derived using regression analysis, wherein the total maturity score obtained for each individual was considered as the independent variable and the corresponding age as the dependent variable in the STATA 15.1 statistical program.

Results: There was underestimation of age in both the sexes by the original method. Regression equations were derived for males and females separately for age five to 18 years and again after adding cases up to 23 years. The estimation was better for males up to 18 years [R^2=0.94, Mean Absolute Error (MAE) 0.747 years and SD 0.644] than for females up to 18 years (R^2 = 0.89, MAE 0.886 years and SD 0.925). The estimation was better for up to 18 years than for up to 23 years in both sexes.

Conclusions: Demirijian's 8 teeth method underestimated age in the study population and thus population specific equations based on the method are better for dental age estimation. The age estimation utilizing the equations from Nepalese population has given acceptable results.

Keywords: Age estimation; demirijian's method; dental age estimation; forensic age estimation; tooth development chart

INTRODUCTION

Forensic age estimation is important in the dead with skeletonized human remains and in the living for civil and criminal proposes.[1] Age estimation is based on physical, skeletal and dental examination.[2] Among the dental age estimation methods, Demirjian's method[3] and its modification are commonly used and they can be used in conjunction with skeletal examination of bones in the first two decades of life.[4] The major bias in age estimation is the differences in growth and development in different ethnic groups.[5,6] So, it is necessary to create databases applicable to each population.

Age estimation studies using Demirjian's method in Nepalese population have presented that the formula from original study is inaccurate but not derived Nepalese population specific formula to derive age.[7-9] The method has been used to derive the population specific formulas in different contexts.[10-14] We had conducted this study to determine Nepal-specific formulas for age estimation which can be applicable for forensic age estimation in our population.

METHODS

This was a cross sectional study using the 352 Orthopantomographs (OPGs) of Nepalese people of age above five years and below 23 years archived in the department of Oral Medicine and Radiology of Gandaki

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Medical College and other centers of Pokhara, Gandaki province of Nepal. The nationality was considered by the permanent address of the patients from the available records. The OPGs were taken as diagnostic modality for some dental treatments. The study duration was from July 1, 2019 to June 30, 2020.

The date of birth and sex of the participants was recorded by one investigator and blinded to the other investigator who scored the developmental stages of the teeth from OPGs. The JPG image of the OPGs were evaluated in Phiewer MacOS image viewer[15] to determine the developmental stages of the teeth. The images of radiographs were evaluated without prior knowledge about the age of the subject. The radiographs were compared to the 'Tooth Development Chart' and assigned each tooth studied with any one of ten developmental stages (0, 1, 2, 3, 4, 5, 6, 7, 8 or 9). The scoring was done following the protocol of Demirjian's eight teeth method.[4] Following the guidelines of this method, tooth formation was divided into ten different stages and the criteria for stages are given for each tooth separately: (0= No crypt, 9= Complete root formation). The eight teeth method makes use of mandibular permanent teeth on the left side — from the central incisor to the third molar. In the seven teeth method, the third molar is not used. If any of the teeth in the left side is missing, then its right counterpart is used. Each stage of the teeth was given a gender specific, biologically weighted score which is different for males and females as proposed by Chaillet and Demirjian.[4] The scores were then added to get a total maturity score (MS) which could be maximum 100. The record of the patients includes the exact date of birth from the patients undergoing OPG and the date of radiograph taken. The age of each individual was calculated as the difference between date of birth provided in the dental records and the date on which the radiograph was taken.

Individuals of known age (inclusion of date of birth in the OPGs) from five to 23 years, who had undergone OPG as a diagnostic modality for some dental treatments were included in the study. Exclusion criteria included those OPGs without proper record of date of birth, individuals with same teeth missing in both mandibular left and right sides because if any such teeth were missing in the left side, the corresponding teeth in the right side were used. The OPGs with hard tissue pathology, undergoing or completed orthodontic treatment, fracture of the mandible and obvious developmental anomalies of the teeth were excluded.

In order to assess potential intra-observer differences, 30 randomly selected radiographs were re-evaluated by an examiner after about a month. The radiographs were also evaluated by another examiner blinded to the other examiner. The Wilcoxon matched-pairs signed ranks test was applied for analyzing intra and inter-observer differences.

Chaillet and Demirjian's cubic functions[4] were tested in the 252 study cases below the age of 18 years (131 males and 121 females) separately for males and females and the estimated age compared with the chronological age using paired samples t test. The testing was done in the study cases below 18 years in order to do fair comparison as the upper age limit in the original study was 18 years. [4] As there was significant difference between the chronological age and derived age in our study population, we derived Nepal-specific formulas from regression analysis, using the total maturity score obtained for each individual to make this method applicable to Nepalese population. Separate formula for males and females were prepared.

The regression equation used was: Age (years) = $\beta_0 + \beta_1 * (S) + \beta_2 * (S)^2 + \beta_3 * (S)^3$

Here, S is the total maturity score, and $\beta_0, \beta_1, \beta_2, \beta_3$ are the parameters of the regression models also called regression coefficients. While β_0 represents the intercept on Y-axis, $\beta_1, \beta_2, \beta_3$ represent linear, quadratic and cubic change in Y (age) for unit change in X (total maturity score). Correlation coefficient is represented by R.

Mean absolute error (MAE) of the age was calculated for the estimated age. The number of estimates was also studied as accurate and inaccurate where the error of ≤1 years was regarded as accurate and ≥2 years as inaccurate as had been done by Ritz-Timme et al.[16] and also adopted by Acharya[12] in an Indian study. This would imply that the errors of 1-2 years would be regarded as acceptable. The error with ≥2 years would also be inappropriate for forensic age estimation. Population specific formulas were derived using regression analysis, wherein the total maturity score obtained for each individual (based on maturity score) was considered as the independent variable and the corresponding age as the dependent variable in the STATA 15.1. Statistical significance level was set to 0.05.

Further, 100 cases above 18 years and below 23 years (62 females and 38 males) were added in order to make the application of the equation to the broader age group which can have forensic significance. The method was successfully used in cases up to 25 years in an Indian study.[12] We had limited the upper age limit to 23 years as the dental maturity was complete beyond that age in our study sample. The research proposal was ethically

approved from Ethical Review Board of Nepal Health Research Council (Ref. No. 1307, Reg No. 711, 2019).

RESULTS

There was no statistically different intra-observer and inter-observer scores upon analysis by Wilcoxon signed ranks test (P value > 0.05). The age and sex distribution of the study cases is shown in table 1.

Table 1. Sample distribution across age-groups and sexes (n=352).

Age (Completed years)	Sex		Total
	Female	Male	
5	14	10	24
6	14	23	37
7	8	21	29
8	15	15	30
9	14	8	22
10	2	9	11
11	5	4	9
12	5	4	9
13	4	8	12
14	8	3	11
15	11	5	16
16	13	11	24
17	8	10	18
18	12	13	25
19	14	9	23
20-22.99	36	16	52
Total	183	169	352

Likelihood ratio test was performed to investigate the association between age and maturity score which demonstrated that the association was cubic. (figure 1) We used the equations from the original study[4] to derive age in our study population for males and females separately below 18 years (at 95% CI). There was underestimation of age in both the sexes by the method. (table 2) The difference in the chronological age and the calculated age was statistically significant (p<0.001).

Regression equations were derived for males and females separately for age five to 18 years and again after adding cases up to 23 years. (table 3) The estimation was better for males up to 18 years (R^2=0.94, MAE 0.747 years and SD 0.644) than for females up to 18 years (R^2 = 0.89, MAE 0.886 years and SD 0.925). The estimation was better for up to 18 years than for up to 23 years in both sexes.

The mean absolute error of the age estimated by the original and our study was calculated in the samples of less than 18 years. (table 4) The MAE was lower for males (0.747 years) than for females (0.886 years). The MAE was smaller in our study (0.813 years) than the original (1.123 years). A total of 183/252 (72.61%) cases were categorized as accurate (<±1 year) and 16/252 (6.34%) as inaccurate, whereas it was 121/252 (48.01%) accurate and 30/252 (11.9%) inaccurate (≥±2 years) by using original formula. As represented in table 2, the mean difference of estimated age from the equations derived from our study was not statistically different from the chronological age of both males (p=0.853) and females (p=0.997) less than 18 years.

Table 2. Paired t-test for comparison of Means of Age with actual age being reference of comparison.

Cases	Variables	Mean (years)	SD	95% CI	P value
Males: N=131 Age<18 years	Actual Age (reference)	10.242	3.954	9.559, 10.926	
	Age from original study[4]	9.488	3.737	8.842, 10.134	<0.001
	Age from our study formula	10.243	3.829	9.581, 10.905	0.993
Females: N=121 Age<18 years	Actual age (reference)	10.987	4.099	10.249, 11.725	
	Age from original study[4]	10.039	3.758	9.363, 10.716	<0.001
	Age from our study formula	10.987	3.893	10.286, 11.687	0.997

Table 3. Regression equations for males and females.

Study participants	Regression Equations [Age (years) = $\beta_0 + \beta_1 . (S) + \beta_2 . (S)^2 + \beta_3 . (S)^3$]	R^2	Mean Absolute error (years)	SD of difference of real age and estimated age
Males 5 to 18 years (n=131)	Age (years) = (0.00004406 * S^3) - (0.00731862 * S^2) + (0.51569745 * S) - 5.3054497	0.94	0.747	0.644
Males 5 to 23 years (n=169)	Age (years) = (0.00011193 * S^3) - (0.01970349 * S^2) + (1.2258773 * S) - 18.163356	0.94	1.024	0.863
Females 5 to 18 years (n=121)	Age (years) = (0.00001003 * S^3) - (0.00033367 * S^2) + (0.06314527 * S) +3.7441727	0.89	0.886	0.925
Females 5 to 23 years (n=183)	Age (years) = (0.00015623 * S^3) - (0.02830971 * S^2) + (1.7565044 * S) - 28.460225	0.89	1.231	1.416

S=Total Maturity Score

Table 4. Error of age estimation (in years) of formulas on <18 years.

Formulas	Mean Absolute error			Error	
	Males (n=131)	Females (n=121)	Males + Females (n=252)	<±1 year (%)	≥±2 years (%)
Nepalese (Our study)	0.747	0.886	0.813	183/252 (72.61)	16/252 (6.34)
Original[4]	0.9641	1.295	1.123	121/252 (48.01)	30/252 (11.9)

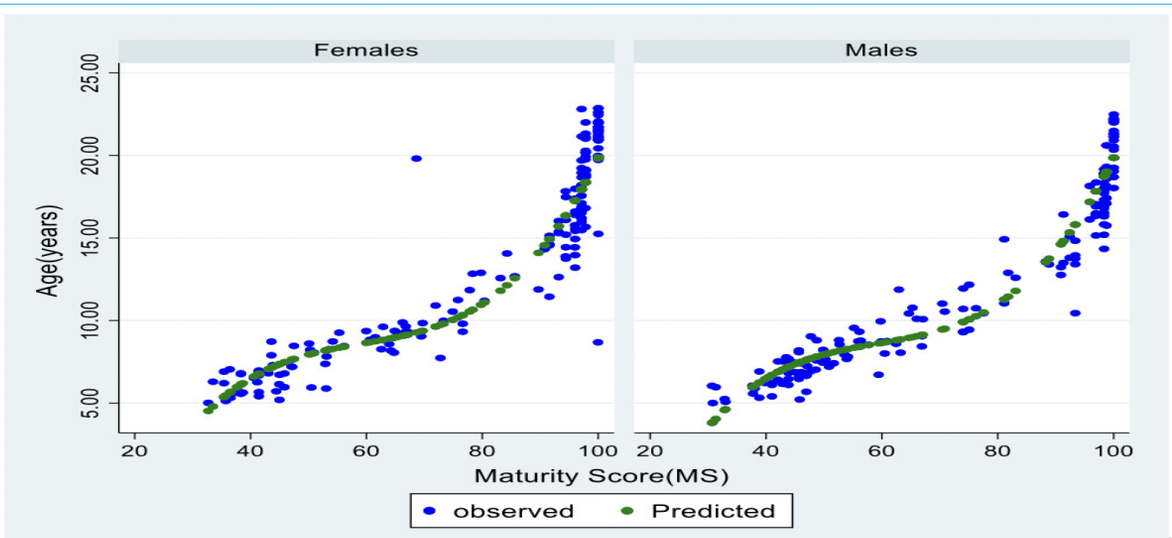

Figure 1. Association between age and maturity score.

DISCUSSION

Forensic age estimation is important in the dead as well as in the living persons. The same method of age estimation may not be accurate in different populations and it is essential for deriving population specific data which can be used with more accuracy in the certain population. Demirjian's method[3] is widely used for dental age estimation and the addition of third molar in the later update by Chaillet and Demirjian[4] has made this method application for up to 18 years of age. As the third molar develops beyond the age of 18 years also, it can have implication beyond that age and this has been used up to 25 years in an Indian study.[12] We have used this method to derive equations from cases with age up to 23 years as the dental maturity was complete beyond that age. The implication of this method beyond the age of 18 years can be important in forensic age estimation and can also be an answer to the legal question whether the individual is more than 18 years or not.

The Demirijian's method was used in several studies and have presented an overestimation[10, 17-21] and others underestimation[11,12] of dental age on different population. The method was tested in an Indian population using equations from original study[4] and an Indian study[12] and the authors found that the error in age estimation with the Indian study was less.[22] In another study from South India, the equations from original study[4] underestimated age and from the Indian study[12] overestimated the age and the authors had advised to develop equations specific to the population studied.[23]

One of the objectives of this study was to know whether the originally derived equation works for Nepalese. In response, this study finds that original equation derived for French population does not hold equally good for Nepalese population. This is because the age estimation done using the original study[4] yielded significant age difference with chronological age in our study cases. This is in accordance with the previous studies.[7-9] Further research is needed to find out the causes of the difference according to population. Secondly, we derived equations for Nepalese. The application of the equations from our study had given more accurate results and the difference of the estimated age from the equations derived and chronological age was not statistically significant. The accuracy could also be explained by the more numbers of cases which fell under the estimates with MAE of <±1 year in our study as compared with the original.[4] The accuracy of dental age estimation decreases with increasing age as the development of teeth would be slowed and finally completed beyond a certain age.[17] In our study also, better age estimation could be done

using the formula till 18 years of age in both sexes. The accuracy of age estimation can be increased by deriving ethnicity specific formulas. To address the forensic needs, the dental age estimation should be used along with other methods, like age estimation from skeletal examination and compiling the results to give a logical age range.

Demirjian's method was used in Nepalese population by Aggrawal et al,[7] Khanal et al[8] and Nyachhyon R.[9] There was underestimation of age in all of the published studies[7-9] and the findings are similar to our observation. These studies used the conversion charts for French population. It highlights the importance of determination of population specific formula for age estimation in Nepalese people and this study has attempted to overcome the need of developing so.

This study has given equations to estimate dental age from Demirijian's eight teeth method in Nepalese population which can be used as a scientific evidence of forensic age estimation. The method can be tested to a broader population and the inter-ethnic variations in the Nepalese people can also be studied further.

Though we have attempted to derive Nepal specific formulas, there can still be variations in different ethnicities of Nepalese population. We can use this method in people of different ethnicity which can give better results in dental age estimation.

CONCLUSIONS

Demirijian's eight teeth method underestimated age in the study population and thus population specific equations based on the method are better for dental age estimation. The age estimation utilizing the equations from Nepalese population has given acceptable results.

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