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Validity of Acharya's population specific standards for age prediction in Hyderabad population: Is there a need for new population specific formulae?

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Abstract

Dental mineralization, compared to skeletal development, is widely considered the most accurate indicator of chronological age in subadults. As dental maturity proved to be varied even within different populations of same country, the present study is designed to evaluate the applicability and accuracy of Acharya's population specific formulae for age estimation in Hyderabad population. This cross-sectional retrospective study was conducted on panoramic radiographs of 186 subjects (91 boys & 95 girls) aged between 7 and 22 years. All the left mandibular teeth were evaluated and scored as per Demirjian's 9- stage criteria. Age was calculated on the basis of Acharya's Indian formula. Statistical analysis was performed to compare the estimated and actual age. All data were analyzed using SPSS 20.0 statistical software and Microsoft excel. The results revealed that these formulae underestimated Dental age in boys by 0.31 years, by 0.16 years in girls and by 0.23 years in both samples. It also revealed that 39% of subjects having an error rate within +/- 1 year, while 38% of subjects falls into error rate of more than +/- 2 years. This high error rate in estimating dental age suggested among studied population suggested the need for formulation of new standards in Hyderabad population.

Keywords: Age estimation; Demirjian's method; Acharya's population specific formulae; Panoramic radiographs

Introduction

The need for age estimation particularly in children, pre-adolescents and adolescents is not just limited for orthodontic treatment planning or for clinical dentistry but it also assumes an imperative role in forensic context. Predicting age of unknown or un recognized cadavers has become vital in practice of forensic medicine, and it is considered as crucial piece of information for police to proceed further in criminal investigations. Age estimation is also carried out in living individuals in medicolegal cases such as rape (both victims and accused), child labor, child marriages and for illegal immigrants who do not have proper valid documentation.

How old is the individual in question? Is he/ she is a major or minor? Are the most commonly questions asked by the crime investigators. As there is significant difference exists between adults and children in legal point of view, the work of forensic experts has become vital and there is expanding interest by the courts for proper estimation of age in these individuals. This even becomes burdensome, when an expert is requested to perform an assessment of age in a living individual for the purpose of providing information that carries significant evidentiary value in legal decisions that determine future outcomes for individuals.(1)

Measuring maturation of Skeletal elements depicts individual's development and details of the size, shape and degree of mineralization of bone define its proximity to full maturity. Further assessment of skeletal maturity involves rigorous examination of multiple factors and mainly assess the way bone develops.(2) Bone age is an indicator of skeletal and biological maturity of an individual.(3) Dental age estimates can also be used as practical method to measure child's degree of maturity. As dental maturation is a continuous, progressive process, visualized radiographically and is least affected by endocrine pathologies, environmental disturbances or other factors such as malnutrition or disease, makes it to be a reliable indicator for age estimation.(4,5)

Among various methods available for age estimation in children, Demirjian method(6) of age estimation has got wider acceptance. In this method seven mandibular teeth on left side were analyzed, also its applicability was verified in Indians which revealed variations in age estimates, and further concluded that it is inaccurate and cannot be applicable for individuals who are above 16 years of age.(7,8) Later, in 2004, Chaillet and Demirjian derived new regression formulae by adding third molar into the analysis.(9) Inclusion of third molar development further expanded its applicability and extended the years of age estimation to 9–23 years as crown and root development can be studied independent of eruption. Owing to ethnic differences in population groups, Acharya(10) from India formulated India-specific formulas to accurately predict the age in Indians. Keeping in mind, the existence of variations in dental maturity within same country,(11) this study is designed to evaluate the applicability and accuracy of Acharya's population specific formulae for age estimation in Hyderabad population.

Materials and Method

Sample: Digital panoramic radiographs (OPTs) of 186 living South Indian (Hyderabad) subjects, aged between 7 and 22 years, were analyzed retrospectively (Table 1).

The OPTs utilized in this study were taken as a part of routine clinical diagnosis from private dental practice and from those who visited forensic medicine department of Osmania medical college, Hyderabad. The inclusion criteria were; subjects between 7 to 23 years, those with known age, good quality OPTs and without medical evidence of any systemic disorders that may affect tooth development. Individuals with missing third molars, unknown date of births, presence of any missing or filled teeth, with periapical pathologies, were excluded from the study.

The details of the studied subjects were entered into an excel sheet separately. To avoid observer errors, each OPT was allotted with identification number, to ensure that the examiner was not aware about the demographic details of the subjects. Chronological age of each subject was calculated by subtracting the date of birth from the date of exposure of the OPT and converted into decimal ages.[11]

Evaluation of dental maturity using Demirjian's 8 teeth method: For estimation of dental age, all the lower left mandibular teeth (from central incisor to third molars) were evaluated. Each tooth was staged 0-9, depending the stage of calcification. The examiners were instructed to assign Demirjian stage to each tooth respectively and later each tooth was allocated with a score depending on the stage. Later the sum of all the scores of 8-teeth gave a total maturity score (S), which was then substituted into the regression formulae (separately for males and females) given by Acharya[10] to estimate age of the subjects. The formulae were listed as follows:

For males, age = $27.4351 - (0.0097 \times S^2) + (0.000089 \times S^3)$

For females, age = $23.7288 - (0.0088 \times S^2) - (0.000085 \times S^3)$

Statistical Analysis: To assess intra-rater and inter-rater agreement of Demirjian staging, intraclass correlation coefficient was reevaluated three weeks after first analysis on randomly selected 30 OPTs. The differences between the estimated dental age (DA) using Acharya's formulae and chronological age (CA) were compared based on gender and age groups with paired t-test. Pearson's correlation test was performed to assess the relation between calculated DA and CA. The accuracy is referred by the mean differences between the estimated age and the real age. In this study, the effectiveness of the tested method was compared by counting the number of age estimates fallen into <+/- 1 year age range (accurate) and those into >+/- 2 years age range (inaccurate) were counted. The statistical level of significance was chosen at $P<0.05$. All statistical analyses were performed using the Statistical Package for Social Sciences Computer software, SPSS version 20.0.

Results

The intra- and inter-observer agreement were ICC =95.4% (95% CI, 92.0%-97.5%) and ICC =91.6% (95% CI, 86.2%-95.5%).

Tables 2 & 3 for both genders compared DA derived from the regression formulae of Acharya's with CA of the subjects among all the age groups. For boys, except 9-9.9, 16-16.9, 17-17.9, 18-18.9 and >19 years, in remaining all age groups significant differences were observed. DA was overestimated in all age groups except for 12-12.9 years and > 19 years age groups. For girls, except for 10-10.9, 15-15.9, > 19 years, statistically significant differences were found in remaining all age groups. DA was overestimated in all age groups except 10-10.9 years and > 19 years age groups.

Table 4 shows mean differences between the DAs and CAs for boys (n=91) and girls (n=95) and in total (n=186) according to the Acharya's formulae. These formulae underestimated DA in boys by 0.31 years, by 0.16 years in girls and by 0.23 years in both samples. Pearson's correlation for boys is r=0.819, for girls r=0.836 and for total sample is r=0.836. This correlation is positive and significant, among all subjects. Figures 1 and 2 shows the accuracy of Acharya's formulae for boys and girls respectively. Figure 3 shows the distribution of results for boys and girls to show the accuracy of the applied population specific formulae of Acharya.

The data tabulated in table 5 gives the year differences in percentages between the CA and DA for all the subjects using Acharya's formulae. For Boys, the difference between the DA and CA was less than 1 year in 36%, less than 2 years in 25% and more than 2 years in 39% of the total subjects. For girls, this difference was less than 1 year in 41% subjects, less than 2 years in 23% and greater than 2 years in 38% of the total subjects.

Table 1: Distribution of sample by age and sex

Age Groups	Boys	Girls
7-8.9	2	3
9-9.9	5	3
10-10.9	6	10
11-11.9	10	9
12-12.9	6	9
13-13.9	12	7
14-14.9	11	10
15-15.9	14	13
16-16.9	3	3
17-17.9	4	2
18-18.9	4	4
>19	14	22
Total	91	95

Table 2: Comparison between DA using the Indian Demirjian formula (Acharya's) and CA (in years) in Boys (n=91)

Age Groups	N	Mean (SD)			p-value
		CA	DA	DA-CA	
7-8.9	2	8.71(0.14)	13.05(2.31)	4.35(2.45)	0.242
9-9.9	5	9.22(0.26)	11.96(0.59)	2.74(0.52)	<0.001
10-10.9	6	10.30(0.23)	10.46(0.13)	0.16(0.18)	0.081
11-11.9	10	11.19(0.27)	11.43(1.18)	0.24(1.33)	0.576
12-12.9	6	12.42(0.42)	11.51(1.09)	-0.90(1.18)	0.120
13-13.9	12	13.36(0.32)	14.05(2.55)	0.69(2.53)	0.361
14-14.9	11	14.28(0.31)	14.91(2.14)	0.62(2.06)	0.340
15-15.9	14	15.38(0.31)	15.96(2.33)	0.58(2.42)	0.385
16-16.9	3	16.30(0.19)	18.10(0.66)	1.80(0.65)	<0.001
17-17.9	4	17.65(0.12)	18.66(0.52)	1.01(0.41)	<0.001
18-18.9	4	18.20(0.19)	19.21(0.44)	1.01(0.42)	<0.001
>19	14	21.25(1.75)	19.17(0.75)	-2.07(1.67)	<0.001

Table 3: Comparison between DA using the Indian Demirjian formula (Acharya's) and CA (in years) in Girls (n=95)

Age Groups	N	Mean (SD)			p-value
		CA	DA	DA-CA	
7-8.9	3	7.40(0.52)	11.43(2.41)	4.03(2.76)	0.127
9-9.9	3	9.43(0.37)	10.58(0.86)	1.14(1.21)	0.243
10-10.9	10	10.20(0.23)	9.98(0.22)	-0.21(0.28)	<0.001
11-11.9	9	11.38(0.32)	12.34(2.09)	0.96(2.18)	0.220
12-12.9	9	12.35(0.38)	12.44(1.93)	0.08(1.99)	0.898
13-13.9	7	13.40(0.37)	14.46(1.56)	1.06(1.67)	0.144
14-14.9	10	14.52(0.23)	15.25(2.33)	0.73(2.27)	0.335
15-15.9	13	15.34(0.28)	16.48(1.62)	1.13(1.70)	<0.001
16-16.9	3	16.60(0.26)	17.14(0.59)	0.54(0.33)	0.105
17-17.9	2	17.45(0.49)	18.76(2.77)	1.31(3.26)	0.670
18-18.9	4	18.13(0.18)	19.64(1.25)	1.51(1.18)	0.083
>19	22	21.51(2.34)	19.38(1.70)	-2.15(2.22)	<0.001

Table 4: Summary of mean differences in years (DA-CA) between the DA and the CA for girls and boys

	n	Mean CA (SD)	Mean DA (SD)	Mean diff. (SD)	95% CI of the difference	t	Sig.	Pearson's correlation
Boys	91	14.66(3.74)	14.97(3.37)	-0.31(2.17)	-0.76, 0.14	-1.365	0.176	0.819*
Girls	95	15.11(4.40)	15.27(3.70)	-0.16(2.33)	-0.63, 0.31	-0.675	0.501	0.836*
Total	186	14.89(4.08)	15.12(3.54)	-0.23(2.24)	-0.55, 0.09	-1.421	0.157	0.836*

***Correlation is significant at the 0.01 level**

Table 5: Year wise differences in percentage between the CA and DA for Acharya's Formulae

Difference from CA	Acharya's formulae		Total (n=186)
	Boys (%)	Girls (%)	
< 1 year	33 (36)	39 (41)	72/186 (39)
1-2 years	23 (25)	20 (21)	43/186 (23)
>2 years	35 (39)	36 (38)	71/186 (38)

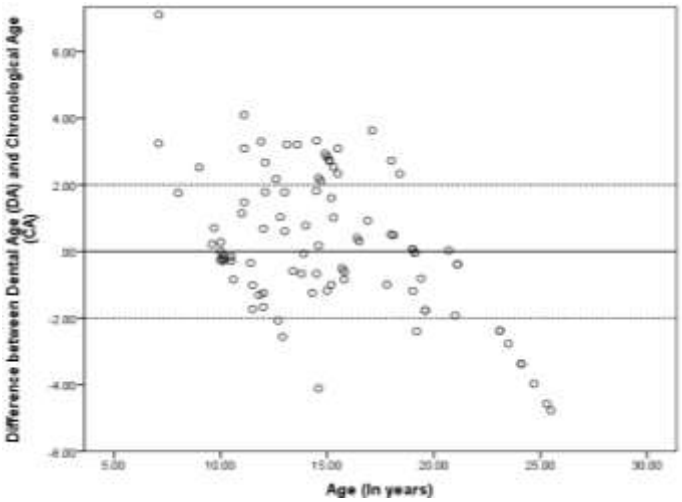

Fig. 1: Accuracy of Indian specific formulae (95% confidence limits of mean accuracy in years) for girls with ages 7.00–22.00 years (Acharya's method)

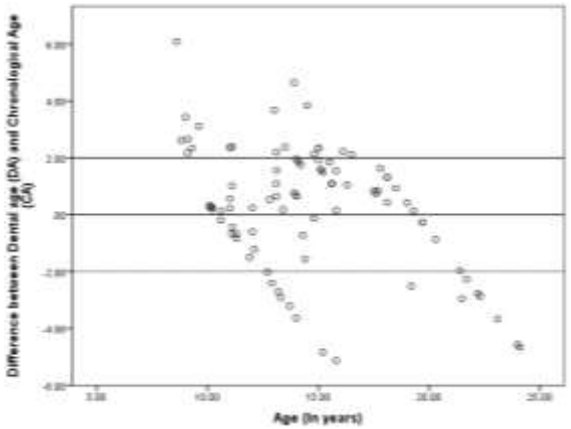

Fig. 2: Accuracy of Indian specific formulae (95% confidence limits of mean accuracy in years) for boys with ages 7.00–22.00 years (Acharya's method)

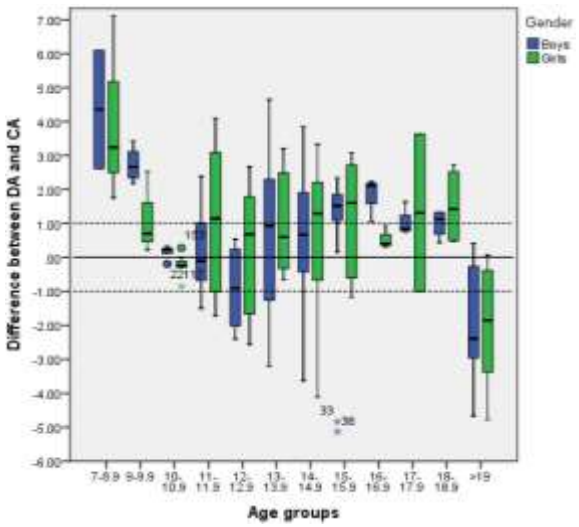

Fig. 3: Boxplot of the difference between the dental age and the chronological age for girls and boys according to Acharya's population specific regression formulae. Boxplots shows median and interquartile range, whiskers indicate the range

Discussion

It is a widely accepted and established fact that age estimation methods (skeletal, dental or sexual maturity) are more accurate when applied to the individuals from the population from which those standards are derived.[1] And when these standards applied to the individuals foreign to original reference population, higher error rates occurred which potentially compromises the applicability of the method.[12-14] Increasing global migrations, environmental factors, increasing intermarriage, relative proportion of usage of extant standards formulated years ago based on foreign reference sample etc., which may not accurately reflect the modern population. This remained to be a strenuous task for forensic practitioners as most of the populations are in need of reliable population specific standards.

Because of simplicity in its methodology, non-invasive (radiographic) in nature and presented with schematic images of tooth development, Demirjian's method has been widely applied in various population groups since many years. However, when these standards were applied to other samples foreign to original reference sample, wide variations were observed between the estimated age and actual age of subjects, suggesting the need for population specific standards.[15,16] As the Demirjian's 8 teeth method proposed by Chaillet and Demirjian[9] produced errored results when applied to Indian sample, Acharya[10] in 2011 formulated population specific standards for Indians. Utilizing these population specific standards, further studies carried out in Indians by Sai Kiran et al.[17] and Tandon et al.[18] where in which the authors concluded that even they are derived from this reference sample, they produced overestimation of dental age and the difference (between DA & CA) ranged from 0 to 4.2 years. As dental maturity proved to be varied even within different populations of same country from above studies, SB Balla et al. recommended the necessity of adapting population standards within country itself.[11] So this study was designed in two parts. The first part was purposed to check the accuracy of Acharya's population specific standards for Hyderabad population. If unreliable results obtained from these standards, the authors designed to carry forward second study which is aimed to formulate new standards for Hyderabad population.

In the present study, for boys (n=91) the mean CA was 14.66 years. The mean DA was 14.97 years with a mean difference of -0.31 years. For girls, the mean CA was 15.11 years and the mean DA was 15.27 years with a mean difference of -0.16 years (Table 4). These results had shown that these population specific standards of Acharya have produced underestimation of dental age for both boys and girls with slight better estimation in girls. These findings were in line to other study (girls predicted accurately over boys) where the authors used Indian formulae.[19] However, in contrast to the findings in this study, boys were accurately predicted in other study, where the authors tested with these Indian formulae.[20] And also significant correlations were found between CA and estimated DA for both boys (r=0.81) and girls (r=0.83).

In this study, the performance of these population specific standards was evaluated age group wise in both boys and girls and results were depicted in Table 2 and 3. The magnitude of mean overestimation of age varied between age groups. It was as high as 4.35 years in boys and 4.03 years in girls in 7-8.9 age groups. When observed, the mean differences between DA and CA were ranged up to 4 years in younger age groups 7-8.9 and 9-9.9 age groups for both boys and girls and in older age groups (>19 years) it ranged up to 2 years in both. "A better method demonstrates the accuracy or smaller difference between DA and CA and the extent to which the estimated ages remain consistent over the repeated measurements".

Determination of dental age using dental maturation can be obtained with an accuracy of "plus or minus one year" particularly at times of prediction of dental age in preadolescents and adolescents. In this study, the authors listed the number of subjects according to the year wise mean differences between DA and CA (Table 5). In boys, 36% (33 out of 91) of individuals fallen into category of +/- 1 year, 25% (23 out of 91) fallen into +/- 1- 2 years difference and 39% (35 out of 91) fallen into category of >2 years. In girls, 41% (39 out of 95) of individuals fallen into category of +/- 1 year, 21% (20 out of 95) fallen into +/- 1- 2 years difference and 38% (36 out of 95) fallen into category of >2 years. These findings suggested that Acharya's population specific standards have identified only 36% of boys and 41% girls which had fallen into acceptable range of age estimation in children i.e., +/ - 1 year. A successful age prediction model must ensure to record the mean differences between DA and CA to stay within the range of +/ - 1 year. This higher error rate (above +/- 2 years) on application of these formulae pointed out the need to reduce these errors. Suboptimal estimates begin to occur once the age crosses beyond 20 years as the development of third molar ceased.

Conclusion

These population specific standards of Acharya have produced better age estimation in girls than boys. But these formulae failed to contain the number of subjects within the acceptable age range for age estimation of children in medicolegal cases. So, further studies are advocated in children of Hyderabad population based on larger reference population.

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