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Dental Age Estimation by Modifying Nolla's Method to Determine the Accuracy in Children in the Region of Mahe

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Abstract

Background: Age estimation has many factors, viz, skeletal age, sexual age, chronological age (CA) and dental age (DA). Assessment of tooth development is widely being used these days for age estimation because of its reliability and ease of procedure. The tooth with its developmental phases impart non-invasive, non-destructive attributes to assess the person's age. However, ethnicity, influence of hormonal and racial factors, environmental changes, and various diseasesmay alter the results in certain areas.

Aim of the study: To estimate the Dental age of children aged 7-10 years by Nolla's method using Orthopantomographs, in the region of Mahe.

Materials and Methodology: 60 digital Orthopantomographs (OPGs) were used for the study to estimate the DA of children, using Nolla's method of DA estimation. Seven permanent teeth in the left mandibular quadrant were assessed as per Nolla's method. This was compared to the other quadrants and the results were analysed to determine the DA. The mean difference between the DA and CA was calculated using a paired t-test. Correlation between CA and DA was analysed using Pearson's correlation coefficient. The statistical analysis was done using IBM SPSS Statistics for Windows, Version 26.0.

Results: The DA of children of Mahe showed under estimation using Nolla's method of age determination. Among the quadrants, the maxillary right quadrant showed the least under estimation or most accurate age estimation.

Conclusion: By using a proper regression equation, the Nolla's method can be made more accurate for age determination in the children of Mahe.

Keywords: Dental age (DA), Chronological age (CA), Nolla's method, Children, Underestimation, Regression equation.

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INTRODUCTION

Age estimation can be done via skeletal age, sexual age, chronological age (CA) and dental age (DA). Assessment of tooth development is widely being used these days for age estimation. Teeth are the most indestructible component of the body and have the least turnover among natural structures, hence they are employed most reliably in age estimation. They not only survive death but also remain virtually unaltered for thousands of years afterward.[1]

The tooth with its developmental phases impart non-invasive, non-destructive attributes to assess children's age. A number of systems have been used to estimate the dental age as stated by the extent of the developmental stages reported in radiographic examinations in permanent teeth. Among the approaches for estimating the age according to the stages of development of teeth, Nolla's radiographic method is widely utilised for both teaching and research in forensic sciences. Nolla's dental age estimation can be done using a panoramic radiograph.[2-4]

Dental age estimation is extremely useful in children as it helps in assessing the dental age of the child which may be advanced or regressed in comparison to their chronological age. This difference in age between DA and CA can help in enhanced diagnosis and patient education and can assess or alter the treatment plan, to be able to bring out the best results for that child. Age estimation using Nolla's method was applied on Mysore and Mangalore population and it was noticed that there was insignificant difference between DA and CA.[4,5]

Mahe, a small town located between two districts of Kerala, is a part of Puducherry and located far away from the parent city and hence consist of a rural population. No study has yet been done in the region for age estimation, using Nolla's method.

MATERIALS AND METHODOLOGY

This retrospective study was conducted after obtaining approval from the Ethical Committee of Mahe Institute of Dental Sciences and Hospital. The parental consent was obtained prior to the study after explaining the procedure thoroughly to them. The study was done on children in the age group of 7-10 years, who visited the department of Pediatric& Preventive Dentistry, from February 2022 to February 2023, for interceptive procedures. Digital Orthopantamograph (OPG) of 60 children (30 boys and 30 girls) who were residing in the region of Mahe, U.T of Pondicherry were selected for this study according to the inclusion and exclusion criteria.

Inclusion criteria:

- Digital OPGs of children of age 7-10 years
- Radiographic presence of full complement of maxillary and mandibular permanent dentition except third molar

Exclusion criteria:

- Radiographs with pathologies
- Radiographs of children with systemic, physical or mental disability
- OPG with missing permanent tooth germ

Nolla's method of Dental Age Estimation

Nolla devised a method of age estimation by evaluating the calcification of the permanent dentition in the left mandibular quadrant. The calcification of permanent dentition was divided into 10 stages such as: 0: Absence of crypt, 1: Presence of crypt, 2: Initial calcification, 3: 1/3rd crown completed, 4: 2/3rd crown completed, 5: Crown almost completed, 6: Crown completed, 7: 1/3rd root completed 8: 2/3rds of root completed, 9: Root almost completed - open apex, 10: Apical end of root completed for each group of teeth like incisors, canine, premolars and molars of maxillary and mandibular arches separately.

METHODOLOGY

The 60 radiographs of children were grouped into 2 groups of boys and girls separately, consisting of 30 subjects each.The date on which the OPG was taken and the date of birth provided in the hospital records were used for calculating the CA of each subject. Calcification of permanent dentition was seen on the OPG and DA was calculated according to Nolla's method. The left side of the mandibular seven teeth has been proposed by Nolla for age estimation. In our study both the right and left sides of the mandibular and maxillary teeth were evaluated, for stages of calcification, for both boys and girls separately. Seven mandibular teeth and seven maxillary teeth on the right and left quadrants were assessed separately, for stages of calcification and their values were recorded. Sum total of each individual was matched with a comparative figure given by Nollain his tablefor the final calculation of the values. Separate tables have been given by Nolla for boys and girls. Table excluding third molars was used for this study.

STATISTICAL ANALYSIS

The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using IBM SPSS Statistics for Windows, Version 26.0. (Armonk, NY: IBM Corp). Graphs, Box plots and Pie diagrams were constructed using the Graph Pad Prism for Windows, Version 9.0 (Graph Pad Software, La Jolla California USA). The Independent samples t-test and a one-way Analysis of Variance (ANOVA) was used to compare the CA with the DA calculated by Nolla's method for both the right and left sides of either arch in boys and girls respectively. Pearson's correlation test was used to correlate the CA with the DA calculated by Nolla's method. Simple linear regression analysis was carried out to assess if the DA calculated by Nolla's method could accurately predict the CA, and to obtain a correction factor (if required). The p-value of ≤0.05 was considered as the level of significance.

RESULTS

The overall mean CA of the study subjects was found to be 8.95±1.048 years. The mean age for the boys was found to be 9.03±0.999 years and that for girls was 8.87±1.106 years. For boys the proportion of underestimation of CA to the DA calculated by Nolla's method was found to be in 20 children (66.67%) in right maxillary quadrant, 20 (66.67%) in left maxillary quadrant, 19 (63.3%) in right mandibular quadrantand 20 (66.67%) in left mandibular quadrant (Table 1). The values were statistically highly significant(p≤0.001).

Table 1: Distribution of study subjects according to estimation status of CA in boys quadrant wise

Status	Maxillary-Right *n* (%)	Maxillary-Left *n* (%)	Mandibular-Right *n* (%)	Mandibular-Left *n* (%)
Correct	7 (23.3%)	7 (23.3%)	9 (30%)	8 (26.7%)
Over estimation	3 (10%)	3 (10%)	2 (6.7%)	2 (6.7%)
Under estimation	20 (66.7%)	20 (66.7%)	19 (63.3%)	20 (66.7%)
p value	<0.001	<0.001	<0.001	<0.001

highly statistically significant (p<0.01)

For girls the proportion of underestimation of CA by the DA calculated by Nolla's method was found to be 21 (70%) in right maxillary quadrant, 24 (80%) left maxillary quadrant, 23 (76.7%) in right mandibular quadrant and 24 (80%) inleft mandibular quadrant (Table 2). The values were statistically highly significant (p≤0.001).

Table 2: Distribution of study subjects according to estimation status of CA in girls

Status	Maxillary- Right *n* (%)	Maxillary- Left *n* (%)	Mandibular- Right *n* (%)	Mandibular- Left *n* (%)
Correct	7 (23.3%)	4 (13.3%)	4 (13.3%)	4 (13.3%)
Over estimation	2 (6.7%)	2 (6.7%)	3 (10%)	2 (6.7%)
Under estimation	21 (70%)	24 (80%)	23 (76.7%)	24 (80%)
p value	<0.001	<0.001	<0.001	<0.001

highly statistically significant (p<0.01)

The proportion of underestimation of CA to the DA calculated by Nolla's method for all the study subjects was found to be 41 (68.3%) in right maxillary quadrant, 44 (73.3%) in left maxillary quadrant, 42 (70%) in right mandibular quadrant and 44 (73.3%) in left mandibular quadrant (Table 3). Nolla's method of dental age estimation underestimated the CA in most of the children of Mahe. It was seen to be correct in a few children. The values were statistically highly significant (p≤0.001).

Table 3: Distribution of study subjects according to estimation status of CA for all the study subjects

Status	Maxillary-Right *n* (%)	Maxillary-Left *n* (%)	Mandibular-Right *n* (%)	Mandibular-Left *n* (%)
Correct	14 (23.3%)	11 (18.3%)	13 (21.7%)	12 (20%)
Overestimation	5 (8.3%)	5 (8.3%)	5 (8.3%)	4 (6.7%)
Underestimation	41 (68.3%)	44 (73.3%)	42 (70%)	44 (73.3%)
p value	<0.001	<0.001	<0.001	<0.001

highly statistically significant (p<0.01)

The difference between CA and DA was found to be in the following order of increase: Mandible<Maxilla in the boys, implying that out of the two arches, the mandible was relatively more accurate than the maxilla in estimating the CA, and, the difference was statistically highly significant (p=0.0075). For girls the difference between CA and DA was found to be in the following order of increase: Mandible<Maxilla, implying that out of the two arches, the mandible was relatively more accurate than the maxilla in estimating the CA, and, the difference was statistically significant (p=0.037). While comparing the whole sample also, it showed that the mandible was relatively more accurate than the maxilla in estimating the CA, and, the difference was statistically highly significant (p=0.0004).

Comparing the difference between CA and DA (in years) between the four quadrants, for the boys, the difference between CA and DA was found to be in the following order of increase Right Maxillary quadrant< Left Maxillary quadrant< Right Mandibular quadrant=Left Mandibular Quadrant, implying that out of all the four quadrants, the right maxillary quadrant was relatively more accurate than the others in estimating the CA, however the difference was not statistically significant (Table 4).

Table 4: Mean Dental Age (in years) estimated by Nolla's Method for the boys included in the study

Mean Chronological Age	Quadrants	Mean Dental Age	Mean Difference	t value	p value
9.03±0.999	Maxillary-Right	8.07±1.285	0.966	3.25	0.0019
	Maxillary-Left	8.03±1.326	1	3.299	0.0017
	Mandibular-Right	7.93±1.311	1.1	3.65	0.0006
	Mandibular-Left	7.93±1.285	1.1	3.701	0.0005

highly statistically significant (p<0.01)

For girls the difference between CA and DA was found to be in the following order of increase: Right Maxillary quadrant=Right Mandibular quadrant < Left Mandibular quadrant < Left Maxillary quadrant, implying that out of all the four quadrants, the right maxillary quadrant was relatively more accurate than the others in estimating the CA, however the difference was not statistically significant (Table 5).

Table 5: Mean Dental Age (in years) estimated by Nolla's Method for the girls includedin the study

Mean Chronological Age	Quadrants	Mean Dental Age	Mean Difference	t value	p value
8.87±1.106	Maxillary-Right	7.73±1.507	1.113	3.32	0.0016
	Maxillary-Left	7.67±1.446	1.2	3.61	0.0006
	Mandibular-Right	7.73±1.53	1.33	3.28	0.0017
	Mandibular-Left	7.82±1.359	1.167	3.516	0.0009

highly statistically significant (p<0.01)

For all the study samples the difference between CA and DA was found to be in the following order of increase: Right Maxillary quadrant < Left Maxillary quadrant < Right Mandibular quadrant > Left Mandibular quadrant, implying that out of all the four quadrants, the right maxillary quadrant was relatively more accurate than the others in estimating the CA, however the difference was not statistically significant (Table 6).

Table 6: Mean Dental Age (in years) estimated by Nolla's Method for all the study subjects

Mean Chronological Age	Quadrants	Mean Dental Age	Mean Difference	t value	p value
8.95±1.048	Maxillary-Right	7.9±1.399	1.050	4.653	<0.0001
	Maxillary-Left	7.85±1.388	1.11	4.899	<0.0001
	Mandibular-Right	7.83±1.416	1.117	4.91	<0.0001
	Mandibular-Left	7.82±1.359	1.133	5.114	<0.0001

highly statistically significant (p<0.01)

Following the statistical analysis, a regression equation was obtained which can be used to do age assessment by Nolla's method in children of Mahe.

Regression equation for boys:

Right maxillary quadrant: 5.674+0.416(DA)

Left maxillary quadrant: 5.729+0.411(DA)

Right mandibular quadrant: 6.318+0.342(DA)

Left mandibular quadrant: 6.039+0.377(DA)

Regression equation for girls:

Right maxillary quadrant: 5.587+0.424(DA)

Left maxillary quadrant: 5.37+0.456(DA)

Right mandibular quadrant: 5.228+0.471(DA)

Left mandibular quadrant: 4.806+0.527(DA)s

DISCUSSION

In comparison to other growth and developmental indicators, dental age is thought to be more relevant to chronological age.[6] Several studies have shown that there was a strong relationship between the DA and CA in mixed dentition population; hence, DA can be considered as a replacement for CA.[7-9] Given that tooth mineralization is largely regulated by genes and is less impacted by environmental variables than gingival emergence or eruption, dental age estimation based on tooth mineralization is claimed to be more accurate than these processes.[6,9] The radiographic method has been determined to be the most beneficial among the numerous dental age assessment techniques since it is straight forward, affordable, non-mutilating, and non-invasive.[5,10] In our study we have used the digital OPGs because they were painless and offer a single, distortion-free image of the whole dentition and since the method was standardised the chance of variation occurring in the technique could be minimised.

There are various ways to calculate DA such as Demirjian's method, Willems method, Modified Cameriere's method, Häävikko methods etc.[11-15] The Nolla's method of dental age estimation was selected because among the methods used to quantify DA, the Nolla's method is reported to be more accurate in different populations.[11,12] This method has added two more degrees of mineralization of crown than the Demirjian's method, in an attempt to make it more precise in assessing dental age.[14] We have used the age groups between 7-10 years because in this age group all the permanent tooth buds except the third molars become visible in the OPG.

Nolla's method makes use of the left mandibular and maxillary teeth to estimate age, since they found that most often the right and left quadrants were found to have the same degree of calcification. His study was done in 1960 and since then many changes have taken place from generation to generation in human beings.[4,5] We have compared the right mandibular and maxillary teeth and left mandibular and maxillary teeth for DA estimation to see if there is any difference between the two sides in children of the present generation.

In this study the CA of the boys and girls was found to be significantly higher than the DA estimated in all the 4 quadrants. We found that Nolla's method of DA determination was underestimation in most of the subjects, when compared to their CA.[3,4,13,14] This was contradictory to the result given by Mohammed

RB *et al* and Noaman BR *et al* where they found that the Nolla's method was overestimation in South Indian population and Kurdish Iraqi population respectively.[15,16]

While taking the efficacy of Nolla's method in maxillary and mandibular arch separately the difference between CA and DA was found to be in the following order of increase: Mandible<Maxilla in boys and girls. This shows that out of the two arches, the mandible was relatively more accurate than the maxilla in estimating the CA, and the difference was statistically significant for all the study subjects (p=0.0004). We found no literature comparing the accuracy of Nolla's method using maxillary and right mandibular arch, hence we could not compare our study result to any other studies. While taking each quadrant the maxillary right quadrant showed the least underestimation or most accurate age estimation and the maximum underestimation was seen in the left mandibular quadrant than the other three quadrants. In case of boys the highest correlation of CA and DA was shown by right maxillary quadrant and least by left mandibular and right mandibular quadrants. For girls the highest correlation was shown by right maxillary and right mandibular quadrants and least by left maxillary quadrant.

Since the Nolla's method of DA estimation was an underestimation in the children of Mahe, we formulated a regression equation to be used for Nolla's method in children of this region. Similar studies formulating the regression equation for Nolla's method was done on Northeastern Chinese children by D Wen *et al*. and Deepthy *et al*. in Mangalore population.[17,5]

While comparing the DA by Nolla's method among boys and girls, our study found that the method is more accurate in boys than in girls.[13,18] This contradicts the study done by Singh *et al* where they found that Nolla's method was more accurate in girls than in boys in North Indian population.[3]

CONCLUSION

This study showed that in girls and boys while taking the two arches, the mandibular arch was more accurate for dental age assessment. While taking each quadrant, the right maxillary quadrant was more accurate than the other quadrants with the Nolla's method. However, when being used for dental age assessment in the children of Mahe, a linear regression equation has to be considered with Nolla's method of age estimation to be able to arrive at an accurate dental age.

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