Reliability of Nolla's dental age assessment method for Lucknow population

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ABSTRACT

Tooth formation is widely used to assess dental maturity and predict the age of growing children. Skeletal age assessment by hand-wrist radiographs has been found to correlate significantly with the growth status of an individual, but has a known drawback in the form of extra radiograph and high dose of radiation exposure in comparison to periapical X-rays used commonly in dentistry. The purpose of this study was to assess the reliability of dental age and to find its comparison with chronological age. Dental maturity was studied from the intraoral periapical radiographs of 90 children aged 9-13 years in Lucknow population with 45 males (age range 10-13 years) and 45 females (age range 9-12 years), and the reliability of dental age estimation using Nolla's method was investigated. The children were radiographed for intraoral periapical X-ray of right permanent maxillary and mandibular canines. Chronological age was obtained from the date of birth of the children. Correlation between the dental age and chronological age was analyzed using the paired *t*-test. Slightly higher mean was recorded in the estimated age (dental age) compared to actual age (chronological age). Females were more advanced in dental maturation than males. Chronological age showed inconsistent correlation with dental age. It was concluded that canine calcification stages can also be used for assessing skeletal maturity.

Key words: Canine Calcification Stages, Chronological Age, Dental Age, Nolla's Method

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INTRODUCTION

Growing individuals not only differ in the timing of the maturational events, but also in the sequence of these events. The developmental status of a child can be assessed from various parameters such as height, weight, chronological age, secondary sexual characteristics, skeletal age, and dental age.[1] These criteria can be applied separately or together to estimate the degree of physiological maturity of a growing child. The tooth with its developmental stages provides us with a noninvasive modality to predict the age of the person.

Dental age is of particular interest to the pediatric dentist and orthodontist in planning the treatment of different types of malocclusion in relation to the maxillofacial growth.[1] In general, there is a good correlation between dental age and chronological age. These correlations can be used as a basis for further therapeutic decisions regarding extracting the primary teeth and timing of the orthodontic treatment. In patients with delayed dental maturity, orthodontic treatment may be started at a later stage, thus leading to the shorter treatment duration and more stable result. In case of over-retained deciduous teeth, the method facilitates determination of the right time for starting treatment. The degree of calcification of different stages of the teeth gives the clinician information about abnormal sequences, so that the preventive measures can be taken on time. The correlation between dental and chronological age is also useful in forensic dentistry as well to estimate the age or to identify the child.[2]

Until quite recently, clinical eruption has been the only criterion used for dental maturity or dental age. Gingival emergence also called eruption represents only one stage in the continuous process of dental eruption. Emergence may be influenced by local factors: Ankylosis, early or

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delayed extraction of deciduous tooth, impaction and crowding of permanent teeth.[1] The timing of eruption of the permanent teeth in relation to race and sex has been studied by several authors. They have investigated the association between emergence and root formation and found large variations between different teeth.[1,3,4] Rate of formation of the permanent teeth is not affected by premature loss of the primary teeth. Many studies have concluded that tooth formation is a more reliable indicator of dental maturity than gingival emergence or eruption.[1,2,5,6] Several authors have shown that dental parameters are more suitable for age estimation in children because the variability is lower since calcification rates of teeth are controlled more by genes than by environmental factors.[1] The result of treatment may sometimes be better evaluated if dental age is assessed in parallel with other maturity indicators.

Dental age estimation is based upon the rate of development and calcification of tooth buds and the progressive sequence of their eruption in the oral cavity. Several methods have been developed to assess the dental age according to the degree of calcification observed in permanent teeth.[6] One such widely used method is that given by Nolla in Figure 1.[7] The relationship amongst the chronological and dental age is important in diagnosis and treatment. Variations of dental and known chronological age indicate changes in the standard growth pattern. Tooth development is also a useful measure of maturity, since it represents a series of recognizable changes that occur in the same sequence from an initial event to a constant end point.

The aims and objectives of this study were the following:

1. Radiographic evaluation of dental age in 9-13-year-old children using Nolla's method
2. To test the applicability of Nolla's method for estimation of chronological age when applied to children of Lucknow
3. To compare the dental and chronological age.

MATERIALS AND METHODS

The present study was conducted on randomly selected 90 healthy children from Lucknow (Uttar Pradesh, India) population in the age group of 9-13 years. Forty-five males (10-13 years of age) and 45 females (9-12 years of age) were selected. The sample was selected from the Outpatient Department of Orthodontics and Dentofacial Orthopedics, King George's Medical College (KGMC), and various schools of Lucknow.

Criteria for case selection

1. The entire sample had parental Lucknow origin.
2. None of the subjects selected had undergone orthodontic treatment.
3. All the subjects selected were moderately built and were of growing age with no history of deformities, bone diseases, and major illness in the past.
4. None of the subjects showed any facial asymmetry.
5. No history of trauma or surgery was reported in the dentofacial region.
6. The subjects with muscular dystrophy, and congenital abnormalities affecting growth and development were excluded.
7. The presence of all the seven left or right mandibular permanent teeth (erupted or not) was considered.

All the subjects were divided into two groups: Group I consisted of males and Group II consisted of females. Each group was further divided into three subgroups on the basis of age as shown in Table 1.

Method

Radiograph of each individual was taken at the Faculty of Dental Sciences, KGMC. The approval was taken from the ethical committee of the concerned institute. Intraoral periapical (IOPA) radiograph of maxillary and mandibular right canine region was taken by using bisecting angle technique with film size 31 · 41 mm (Kodak). The film was exposed to 60 kV power for 1.4 seconds. A brief history of each child including name, age, sex, date of birth, name of the school and address were recorded. Consent was obtained from the parents and school teachers. In the present study, radiographic interpretation was made as per the system developed by Nolla[7] to interpret dental maturation. IOPA radiographs of maxillary and mandibular permanent right canine were assessed for dental age according to Nolla's[7] calcification stages [Figure 2].

Nolla's developmental stages

The Nolla's developmental stages are given below.

Stage 10: Apical end of root completed
Stage 9: Root almost complete; open apex
Stage 8: Two-third of root completed
Stage 7: One-third of root completed
Stage 6: Crown completed
Stage 5: Crown almost completed
Stage 4: Two-third of crown completed
Stage 3: One-third of crown completed
Stage 2: Initial calcification
Stage 1: Presence of crypt
stage 0: Absence of crown.

Error of measurements

To evaluate the magnitude of error in the measurements of various stages of tooth development, repeated determination was carried out on 10 individuals at an interval of 15 days. These tracings were analyzed

separately and two sets of readings were obtained from each case. The reliability of the measurements evaluated by "*t*" test was not found to be statistically significant.

Statistical analysis

Mean, standard deviation, and standard error were calculated for all the groups, and correlation coefficients were computed for the samples collected. The Student–Newman–Keul's test was employed to evaluate the difference between the mean values of chronological age and canine calcification stages.

RESULTS

Tables 2 and 3 show the norms for maturation of maxillary and mandibular right canines for males and females, respectively.

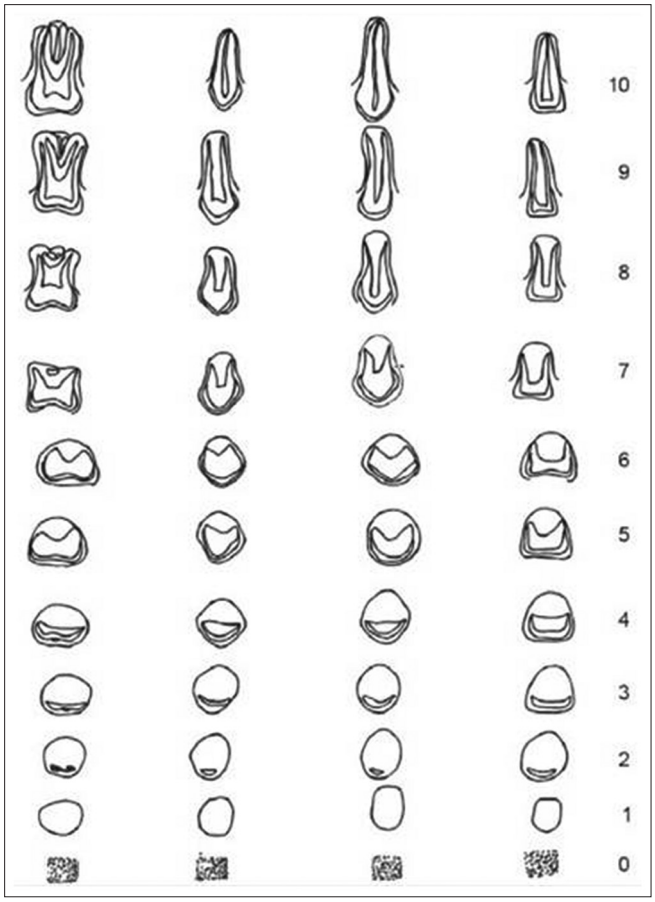

Figure 2: Nolla's developmental stages of permanent teeth

Tables 4 and 5 show a comparison of chronological age with calcification stages of maxillary and mandibular right canines, respectively, for both males and females.

DISCUSSION

The dental system is an integral part of the human body; its growth and development can be studied in parallel

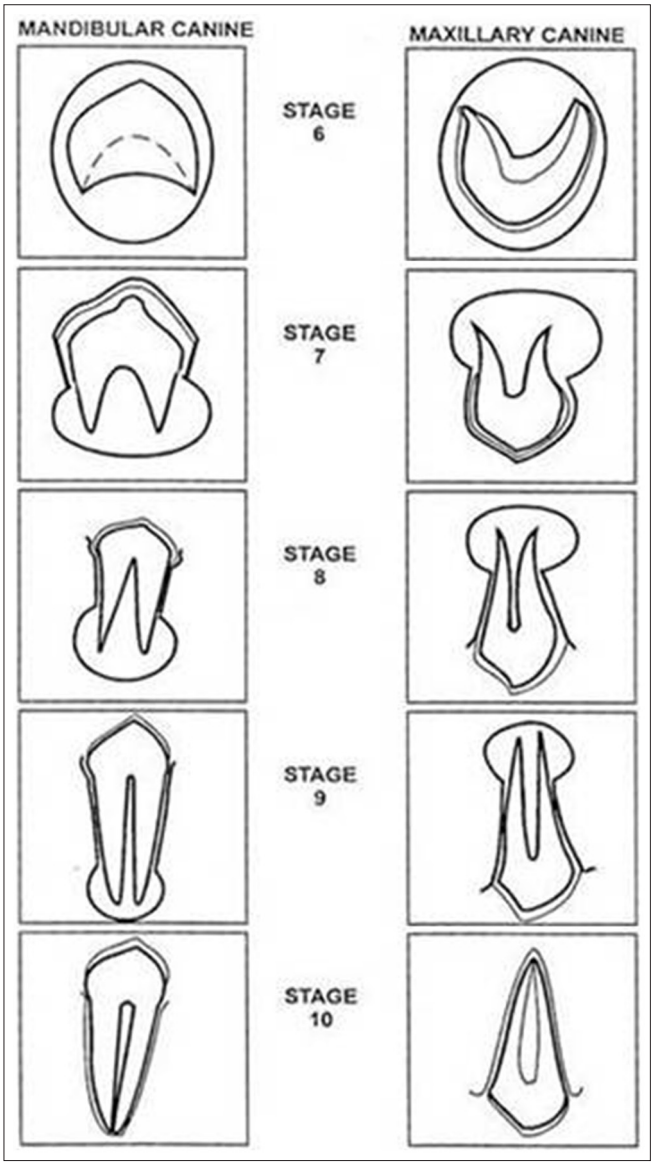

Figure 1: Calcification stages of maxillary and maxillary canines (according to Nolla's method)

Table 1: Grouping of subjects

Group I (male subjects)			Group II (female subjects)		
Subgroup	Age (years)	No. of subjects	Subgroup	Age (years)	No. of subjects
a_1	10-11	15	a_2	9-10	15
b_1	11-12	15	b_2	10-11	15
c_1	12-13	15	c_2	11-12	15
	Total	45		Total	45

with other physiological maturity indicators such as bone age, menarche, and height.[5] Tooth eruption is mostly influenced by environmental factors such as available space in the dental arch, extraction of primary teeth, tipping or impaction of teeth.

The Nolla's scoring system, based on the developmental stages of teeth, is more useful because tooth development is less influenced by environmental factors.[2] In the present study, dental age in 9-13-year-old children was evaluated using Nolla's method that is based on the developmental stages (0-10) of the permanent right maxillary and mandibular canines. Dental age was given according to the developmental stages of permanent maxillary and mandibular canines. When Nolla's method was applied to Lucknow population, the mean difference between actual (chronological) age and estimated (dental) age was found to be insignificant. Comparison of chronological age with mandibular and maxillary right canines' age for subgroup a_1 (10-11 years) a_2 (9-10 years), b_1 (11-12 years) b_2 (10-11 years), and c_1 (12-13 years) c_2 (11-12 years) was not significant ($P > 0.05$), which shows the development of mandibular and maxillary canines was advanced according to the increase in age. This indicates that both are in the same direction in advancement [Tables 2 and 3]. This study was supported by Anderson and coworkers[8] who found that dental development was related more strongly to morphological development than to skeletal development in both sexes. This study was also supported by the report of Lemons and Gray.[9] They reported that chronological age is a better index of tooth development than of hand-wrist development.

Table 2: Norms for the maturation of permanent teeth for boys

Age (years)	Mandibular canine teeth (growth stage)	Maxillary canine teeth (growth stage)
3	3.2	3.0
4	4.2	3.9
5	5.1	4.8
6	5.9	5.6
7	6.7	6.3
8	7.4	7.0
9	8.0	7.7
10	8.6	8.4
11	9.1	8.8
12	9.6	9.2
13	9.8	9.6

Table 3: Norms for the maturation of permanent teeth for girls

Age (years)	Mandibular canine teeth (growth stage)	Maxillary canine teeth (growth stage)
3	3.4	3.3
4	4.4	4.3
5	5.4	5.3
6	6.3	6.2
7	7.2	7.0
8	8.0	7.8
9	8.7	8.5
10	9.2	9.1
11	9.7	9.5
12	10.0	9.8
13		10.0

The development of maxillary canine is slower than that of mandibular canine. This study was also supported by Schour and Masseler[10] who reported that the lower teeth tend to appear earlier than the upper teeth. In addition, they also found out that teeth tend to erupt earlier in females than in males. This study also confirms this finding because the mean of developmental stages of canines of females was greater than that of males, as in females, at 11–12 years of age, the mean of developmental stages of maxillary and mandibular canines was 9.67 ± 10.23 and 9.88 ± 10.15, respectively, but in males it was 9.12 ± 10.17 and 9.36 ± 0.29, respectively.

Comparison was made between the age assessed by developmental stages of maxillary and mandibular right canines and chronological age; the *P* value was not found to be significant ($P > 0.05$) for all subgroups of males [a_1 (10-11 years), b_1 (11-12 years), and c_1 (12-13 years] and females[a_2 (9-10 years) b_2 (10-11) c_2 (11-12 years)] [Tables 4 and 5]. It indicates that both the age assessed by mandibular right canine and the chronological age advanced in the same direction for all subgroups. It is more or less similar to chronological age.

The findings of this study are supported by Green[11] who found that dental age showed the highest degree of correlation with chronological age ($r = 0.6774$) and the lowest correlation with skeletal age ($r = 0.4616$). Lauterstein[12] supported this study by his study finding that chronological age bore a positive correlation to the number of erupted teeth.

Nolla's method was designed primarily for use by clinicians who wanted to know if the dental maturity of an individual deviates from the normal. This can be used as an adjunct to the radiological examination for calcification of maxillary and mandibular teeth. In forensic medicine, dental age is of broader importance not only for the identification of deceased victims but also in connection with accidents and crime cases. There was insignificant difference between chronological age and the age assessed by maxillary and mandibular right canines. This indicates that dental maturation in terms of development of canine also increased as the chronological age. This study was supported by Anderson and coworkers[8] and Lemons and Gray.[9]

Table 4: Means, SD, and SE for the developmental stages of maxillary canine, age by developmental stages of maxillary canine, and chronological age; also shows comparison between chronological age and age by developmental stages of maxillary right canine

Subgroup	No.	DS of maxillary canine			Age assessed by dev. stage of maxillary canine			Chronological age			Comparison between chronological age and age by stage of maxillary canine	
		Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	NKT value	"*P*" value
Group I: Males												
A_1	15	8.44	0.35	0.09	11.20	0.68	0.17	10.47	0.29	0.07	2.15	<0.05
B_1	15	9.12	0.17	0.04	11.80	0.41	0.11	11.56	0.20	0.05	2.76	<0.05
C_1	15	9.36	0.29	0.08	12.40	0.74	0.19	12.45	0.26	0.07	NS	<0.05
Group II: Females												
A_2	15	8.61	0.35	0.09	9.20	0.56	0.12	9.41	0.22	0.06	2.09	<0.05
B_2	15	9.26	0.27	0.07	10.27	0.46	0.12	10.46	0.28	0.07	2.17	<0.05
C_2	15	9.67	0.23	0.06	11.60	0.74	0.13	11.52	0.30	0.08	NS	<0.05

A value of *P*<0.05 was considered statistically significant. *P*>0.05, not significant, SD: Standard deviation, SE: Standard Error, DS: Development stage

Table 5: Means, SD, and SE for developmental stage of mandibular right canine, age by mandibular right canine, and chronological age; also shows comparison between chronological age and age by developmental stage of mandibular right canine

Subgroup	No.	DS of mandibular canine			Age by dev. stage of mandibular canine			Chronological age			Comparison between chronological age and age by stage of mandibular canine	
		Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	NKT value	"*P*" value
Group I: Males												
a_1	15	8.69	0.36	0.09	11.20	0.68	0.17	10.47	0.29	0.07	2.15	<0.05
b_1	15	9.40	0.25	0.07	11.60	0.51	0.13	11.56	0.20	0.05	0.46	<0.05
c_1	15	9.57	0.26	0.07	12.13	0.74	0.19	12.45	0.26	0.07	NS	<0.05
Group II: Females												
a_2	15	8.79	0.31	0.08	9.20	0.56	0.12	9.41	0.22	0.06	2.09	<0.05
b_2	15	9.28	0.14	0.04	10.27	0.46	0.12	10.46	0.28	0.07	2.17	<0.05
c_2	15	9.88	0.15	0.04	11.60	0.57	0.13	11.52	0.30	0.08	NS	<0.05

A value of *P*<0.05 was considered statistically significant. *P*>0.05, not significant, SD: Standard deviation, SE: Standard Error, DS: Development stage

As per this study, canine calcification stage 9 was related to capping of the third middle phalanx and appearance of the adductor sesamoid of the thumb. Hence, maxillary and mandibular canine calcification stage 9 (10-11 years for girls and 12-13 years for boys) confirmed the attainment of peak height velocity (PHV).

Stage 9 of the maxillary and mandibular canines, i.e., the walls of the root canal are parallel and its apical end is still partially open, coincides with the PHV; calcification between stages 8 and 9 could be used to identify the early stage of pubertal growth spurt. As these stages could be assessed on IOPA, this could prove more economical and convenient as the armamentarium required is much simpler and even the radiation dose is less. The information on the development of teeth is important not only for reasons of diagnosis and treatment but also for more detailed purposes of research. Calcification of teeth may, in this way, be used as a criterion of dental age in a patient as it provides an index of physiologic maturity of permanent dentition.

Many investigators have studied the development of the dentition by applying different techniques for observation. This study has adopted Nolla's technique due to its applicability and accuracy.[13-15]

It can be inferred that dental age can be used reliably for assessing dental maturity, but insignificant difference was observed between chronological age and maxillary and mandibular canine calcification stages for all subgroups. This confirmed the reliability and validity of canine calcification stages to be used as a dental maturity indicator. This also eliminated the use of additional radiographic exposure (hand-wrist radiograph) of patients in orthodontic practice, because canine is recorded on IOPA radiograph.

In this study, females were ahead in dental maturation than males in all the age groups. This is supported by the reports of Hagg and Taranger,[16] Castellanous *et al.*,[17] Koshy and Tandon,[18] Prabhakar *et al.*,[19] Hunter,[20] Fishman,[21] and Hafez.[22]

Results of the present study show insignificant difference

in dental development between males and females. The study results were supported by Nolla.[7]

The technique has the advantages of being simple, using low patient radiation dose, and exhibiting high degree of clarity of the radiographs. The equipment required is available in most dental clinics. Hence, Nolla's method for dental age estimation is reliable on Lucknow population.

To conclude, it could be stated that assessment of maturation is of utmost importance in certain orthodontic protocols such as for myofunctional therapy, before starting with rapid maxillary expansion, and for timing of ortho-surgical procedures (surgery for mandibular setback should carried out only after mandibular growth has completed). As the chronological age cannot show accurate status of individual's so we can use canine calcification stages on periapical radiographs which are easier and cheaper to procure than hand wrist X-rays. To further validate the results of this study, it should be carried out on a larger sample size and in varied age groups.

CONCLUSION

1. Females are ahead in dental maturation than males
2. There was insignificant difference between dental age and chronological age
3. Canine calcification stages could also be used as a dental maturity indicator.

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