

**TECHNICAL NOTE****ODONTOLOGY**

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## Is the Assessment of Dental Age by the Nolla Method Valid for Eastern Turkish Children?

**ABSTRACT:** The aim of this study was to investigate whether or not the Nolla method is appropriate for Turkish children for the determination of the dental age (DA). A group of 719 children between the ages of 6 and 18 years were included in the study. DAs from orthopantomograms by the Nolla method were estimated. The results obtained were compared with chronologic age (CA). Paired *t* and the Wilcoxon tests were performed. Both genders were underestimated in dental maturity when compared with the reference samples in total (−0.3 years) ( $p < 0.01$ ). The differences in girls were statistically significant in total and in all groups except for 7–7.9. The differences in boys between the CAs and DAs were not statistically significant in total and in all groups except for 7–7.9 and 8–8.9. Although the accuracy of this method was suitable for boys, according to our findings, it was not suitable for girls.

**KEYWORDS:** forensic science, dental age, chronologic age, Nolla's method, Turkish children, age estimation

Dental maturity, expressed as a dental age (DA), is one of the age estimation methods. Especially in pediatric dentistry, more attention is usually paid to the patient's DA rather than to their chronologic age (CA) that both parameters do not always coincide. Besides, the estimation of dental development is one of the methods most widely used in forensic and legal dentistry (1). The DA of children can be based on dental emergence or on the stages of tooth formation observed in radiographs. The assessment of stages of tooth formation is considered a better method to determine the CA rather than the tooth, the clinical emergence of which is scarcely influenced by local and systemic factors (2–6).

Several methods have been used to determine the DA according to the degree of the calcification observed in radiographic examinations in permanent teeth (7–12). Among all methods used to assess DA, the method devised by Nolla (12) which was preferred in this study is commonly used in teaching and clinical practice (1). In the literature, this method may be used specifically because of several reasons, such as (i) intra-observer agreement in its application is well over 90% (13,14), (ii) it offers two more degrees of mineralization of the crown than the more frequently used method according to Demirjian et al. (8,13), (iii) the results obtained by this method are no less reliable than those obtained by other methods, and the reliability of the method greatly depends on the experience of its application (13,15,16). No study has assessed the reliability of the Nolla

method in Turkish children, and thus, this report will be the first investigating the assessment of DA with the Nolla method in Turkish children. Even if different methods also have been used in the determination of the DA in the Turkish population, various investigators have demonstrated differences between geographical areas or cities within the same country groups because of predominant ethnic origin, climate, nutrition, socioeconomic level, and urbanization, as well as racial variations (17,18). We investigated, therefore, the reliability of the Nolla method for eastern Turkish children.

### Materials and Methods

In this retrospective study, panoramic radiographs of 730 Caucasian Turkish children of known CA and gender were selected. The radiographs of the children were randomly selected from the subjects attending the Faculty of Dentistry of the University of Ataturk (Turkey). All radiographs were performed by an X-ray technician who had a minimum working experience of 5 years as of 1996, using an orthopantomography device (Planmeca Proline CC 2002, 60–80 kVp, 8–10 mA, 12.8 sec exposure time, Helsinki, Finland) with a magnification factor of 1.2. Approval from the ethics committee was not required for this retrospective study. Children who were excluded from the study included the following: agenesis of teeth, poor quality of panoramic radiographs, or image deformity affecting mandibular permanent teeth, physically and mentally healthy with no previous history of chronic or severe illnesses. Eleven children were excluded from the study. Final samples were 409 girls and 310 boys, and their ages ranged between 7 and 18 years. Table 1 shows the distribution of patients by gender and age. All assessments were performed in a darkened room with a radiographic illuminator to ensure contrast enhancement of the tooth images.

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TABLE 1—Age and gender distribution of the subjects examined.

CA	Female	Male	Total (%)
7–7.9	22	12	34 (4.7)
8–8.9	10	19	29 (4.0)
9–9.9	35	21	56 (7.8)
10–10.9	37	25	62 (8.6)
11–11.9	34	41	75 (10.5)
12–12.9	54	51	105 (14.6)
13–13.9	57	66	123 (17.1)
14–14.9	44	35	79 (11.0)
15–15.9	47	15	62 (8.6)
16–16.9	47	17	64 (8.9)
17–17.9	22	8	30 (4.2)
Total (%)	409 (56.9)	310 (43.1)	719 (100.0)

### Chronologic Age

CA was calculated by subtracting the date of the birth from the date of the panoramic radiograph after having converted both to a decimal age.

### Dental Age

The stage of calcification was estimated for all permanent teeth following the system proposed by Nolla (12) in 1960, who considers that the degree of calcification is based on 10 stages of maturity moving from stage 1 (no sign of calcification) to stage 10 (apical end completed), besides a 0 stage that points out the absence of dental germs. As the process of calcification is continuous, the author suggests that the accuracy of the estimation is increased by using decimal fractions (fractions of the stage) in those cases where the stage of calcification is between two correlative stages. If one-third of the crown was completed, the observation was given the value 3.0; if one-third of the root was completed, the observation was graded 7.0. When the radiograph reading lay between two grades, this appraisal was indicated as the value 0.5 and the observation corrected to 7.5. When the radiograph showed a reading that was only slightly greater than the illustrated grade, but not as much as half way between that stage and the next, the value 0.2 was added. When the radiograph showed a reading that was only slightly less than the illustrated grade, the value 0.7 was added. The sum of scores was compared to the average sum for boys or girls and DA calculated.

### Reproducibility

Dental and skeletal maturation assessments were performed independently by two investigators (one assistant professor in dentomaxillofacial radiology and the other researcher in pediatric dentistry) without any knowledge about the children's CAs. To check for the diagnostic reproducibility of the interreliability of the two investigators, 10% of the radiographs assigned by them were randomly examined each day for three consecutive days. Examination of results using the Wilcoxon matched-pairs signed-rank test showed no statistically significant differences between the two observers, indicating diagnostic reproducibility. In addition, 10% of the remaining radiographs were selected at random and reevaluated twice by the same examiner 6 weeks after the first evaluation. Intra-examiner reproducibility was found to be 96 and 90%, respectively.

### Statistical Analysis

All descriptive and comparative statistical analyses were performed using the SPSS software package (Statistical Package for

Social Sciences, version 11.5; SPSS Inc., Chicago, IL). The Kolmogorov–Smirnov test was performed to test for the normality of DA distributions. Then, paired *t*-test was performed for the parameters showing normal distribution, and the Wilcoxon test for the parameters showing abnormal distribution.

### Results

Differences between the mean CAs and estimated DAs according to the Nolla method are presented in Table 2. Both genders were underestimated in dental maturity when compared with the reference samples. The mean difference between the CAs and DAs was  $-0.3$  years in total. This difference was statistically significant ( $p < 0.01$ ).

The mean difference between the CAs and DAs ranged from  $-0.1$  to  $-1.0$  years in girls. These differences in girls between the CAs and DAs were statistically significant in total ( $p < 0.01$ ) and in all groups except for 7–7.9 ( $p > 0.05$ ). The mean difference between the CAs and DAs ranged from 0.0 to  $-0.6$  years in boys. These differences in boys between the CAs and DAs were not statistically significant in total ( $p > 0.05$ ) and in all groups except for 7–7.9 and 8–8.9 ( $p < 0.001$ ).

### Discussion

DA correlates closely with CA in child development. Studies have shown that dental development relates more closely to CA than skeletal, somatic, or sexual maturity indicators. Tooth formation has been more widely used than tooth eruption for assessing dental maturation because it is a continuous and progressive process that can be followed radiographically, and most teeth can be evaluated at each examination (1–6).

TABLE 2—Differences between CAs and DAs determined by Nolla's method.

Age	Mean CA	Mean DA	Mean Differences	<i>p</i> Value
Girls				
7–7.9	7.3	7.2	-0.1	0.318
8–8.9	8.8	8.3	-0.5	0.020*
9–9.9	9.5	9.2	-0.3	0.000***
10–10.9	10.3	9.8	-0.5	0.001**
11–11.9	11.4	11.1	-0.3	0.011*
12–12.9	12.4	11.6	-0.8	0.000***
13–13.9	13.4	12.6	-0.8	0.000***
14–14.9	14.3	13.7	-0.6	0.000***
15–15.9	15.3	14.8	-0.5	0.000***
16–16.9	16.4	15.4	-1.0	0.000***
17–17.9	17.2	16.7	-0.5	0.000***
Total	12.4	11.9	-0.5	0.002**
Boys				
7–7.9	7.6	7.1	-0.5	0.000***
8–8.9	8.8	8.5	-0.3	0.000***
9–9.9	9.3	9.3	0.0	0.515
10–10.9	10.5	10.0	-0.5	0.097
11–11.9	11.3	11.2	-0.1	0.051
12–12.9	12.5	12.3	-0.2	0.552
13–13.9	13.4	13.3	-0.1	0.058
14–14.9	14.4	13.8	-0.6	0.278
15–15.9	15.5	15.2	-0.3	0.057
16–16.9	16.1	16.0	-0.1	0.519
17–17.9	17.3	17.2	-0.1	0.076
Total	12.4	12.2	-0.2	0.232
Total	12.4	12.1	-0.3	0.001**

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .  
CA, chronologic age; DA, dental age.

Today, several different methods to determine dental development are available. Demirjian's method is to determine the beginning of mineralization up to the end of root formation. These authors looked at eight mineralization stages for premolars and molars (A–H) and six steps (C–H) for incisors and canines (8,9). Although the method of Demirjian was one of the simplest, practical, and widely used methods, Caro and Contreras (19) found the method of Nolla to be more accurate than other methods they tested. This method that was preferred in our study evaluates 10 mineralization stages of each tooth.

There have been reports carried out for other populations, showing a great variability in the dental maturation process when using the Nolla method (1,13,17,20,21). This shows the necessity to create representative databases for each population to reach a better comprehension of human dental maturation. However, such a research had not been taken up in Turkey, yet. For this reason, the aim of this study was to assess the applicability of the Nolla method in a Turkish population and thus to compare the dental maturity with that of other populations.

Legovic et al. (13) concluded that the accuracy of age estimation by means of lower third molar development based on Nolla's method is applicable for Croatian children. Bolanos et al. (1) suggested that the best estimates were provided by teeth 43, 47, 46, and 44 from boys and teeth 44, 47, and 43 from girls. Several authors (12,18) have shown that there are no significant differences between the right and left sides and that the rate of growth was approximately the same on both sides. Thus, in this study, all of the mandibular right teeth were evaluated to determine the dental maturation according to the Nolla method.

The most interesting conclusion of our study is underestimation of a rate by 0.3 years in the dental development in Turkish children when the Nolla method was used for DA estimation, because advanced DA was determined in the studies that have been carried out before in the Turkish population on this subject by using Demirjian's (22,23). First, it was detected that advanced dental maturity ranged from 0.5 to 1.4 years in girls and from 0.4 to 1.4 years in boys in a recent study published in the northern Turkish population (22). Second, Mentis et al. (23) found advanced dental maturity in the northwestern Turkish population. Otherwise, the difference might be because of many variables, including the sample sizes examined in different regions, precision of the method, age structure of the sample, statistical approach, and biological variation of individual children.

It was also previously stated that sex differences do exist and need to be taken into account. With most maturational events, the tempo of maturation is faster in girls (6). This is in contrast with the findings of this study because the mean differences between DA and CA were 0.5 years for girls and 0.2 years for boys. That is, girls were more underestimated than boys regarding the DA. In addition, significant differences in the dental development for 7–7.9 and 8–8.9 years were observed in boys, and thus, the applicability of this method for boys after 9 years would be expected to be more accurate. Holtgrave et al. (24) reported no difference in girls using the Nolla method; in boys, however, dental development was accelerating, being most apparent in very young boys. Kurita et al. (17) found no significant difference between genders. The difference might be because of the racial and biological variation of the study samples.

Maber et al. (20) showed a consistent underestimation of the mean accuracy for Nolla's maturity scale compared with other methods. The underestimated DA found by Kurita et al. (17) was not observed by Freitas et al. (25) who reported an overestimation in younger children and an underestimation in older-age children of southeast Brazil.

In literature, differences in dental development could exist between different ethnic groups. It was detected that the methods of conversion to DAs depend on the population at issue. Therefore, adaptations might be applied for each region. In view of this, correction factors must be established to make the methods proposed by Nolla applicable to each studied population.

Finally, girls showed delayed formation of permanent teeth, and significant difference was observed between the estimated DA and the CA in this study. In boys, in contrast, there was no significant difference between the DA and the CA. In other words, the applicability of Nolla's method revealed differences between genders. These data support the need for population-specific standards.

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