Accuracy of age estimation with Demirjian and Nolla methods in Eastern Turkish children aged 3-17 years old

Gulsum Duruk1 ORCID, Tamara Pelin Gundogdu, Ozdal1 ORCID, Sacide Duman1 ORCID

Introduction

Age determination has become an important aspect in current practice. The biological age determination method performed via dental age assessment is one of the methods that are easy to use (1). Dental age assessment helps to make decisions for the treatment procedures both in pediatric dentistry and in orthodontics. Chronological age assessment with the help of dental age also provides great convenience for children who do not have birth certificates, in natural disasters and criminal events (2, 3). Age determination methods used in the field of forensic medicine provide important information about unidentified persons, and also play an important role in the determination of child marriages and child labour (3). In addition, age determination has an important place in the field of medicine and dentistry for the treatment programs designed for the refugee families or children with no identity.

There are many methods related to maturation of permanent teeth and chronological age assessment from dental age. Morrees, Kvaal, Willems, Haavikko, Liliequist, Lundberg, Demirjian, and Nolla are...
some of them (4-12). Demirjian and Nolla methods are the two most commonly used methods in chronological age estimation. Different results related to dental age can be found in different geographies. The studies conducted in Turkey on the dental age assessment with the Demirjian and Nolla methods are available in the literature (1, 9, 10, 13-15).

Kirzioglu and Ceyhan (9) compared the Nolla and Demirjian methods in 425 Turkish children aged 7-13 years who share the similar socio-economic status and the ethnic group. An underestimation of −0.53 years was found for boys and −0.57 for girls with the Nolla method, this method being more accurate between 9 and 11 years in both genders and in the group of 13-year-old girls. However, the Demirjian method overestimated boys’ age by +0.52 and girls’ age by +0.75. Kirzioglu and Ceyhan (9) reported that both methods are not totally suitable, with makes it necessary to assess specific tables for this population.

Each population may need their own specific standard for an accurate estimation of chronological age. Since different results are obtained in different countries and regions, there are not many studies that utilize the Demirjian and Nolla methods in Turkey. Therefore, in our study, it was aimed to perform the dental age assessment by using the Demirjian and Nolla methods on the panoramic radiographs taken from children in the Eastern Anatolia Region of Turkey and to bridge the gap due to an insufficient number of studies conducted in our country on this subject. The null hypotheses of this study were as follows: There is no statistically significant difference between the chronological age and dental age. There is no statistically significant difference between the chronological age estimation values according to the Demirjian and Nolla methods.

Materials and Methods

Ethical approval

The present study was approved by the Non-Interventional Clinical Research Ethics Committee of İnönü University, Malatya, Turkey (2020/856).

Sample size estimation

This was a retrospective study conducted on panoramic radiographs. For a confidence level of 90% and α = 0.05, at least 271 subjects were needed. The sample consisted of 1587 subjects’ panoramic radiographs (774 females and 813 males, ages 3-17.9, (Table 1)).

Study materials

Panoramic radiographs from the subjects who underwent treatment at İnönü University, Faculty of Dentistry, Malatya, Turkey, between January 2016 and December 2017 were included in the study. Eastern Turkish subjects with well-documented chronological ages, aged 3-17.9 years with no prior orthodontic treatment history and good quality of panoramic radiographs were included. Our study did not involve the subjects with systemic diseases affecting the growth and development of the teeth and tooth agenesis other than third molars, vagueness in dental structures due to contrast problems, movements or artifacts, impacted teeth; radiopaque obturations or crowns, periapical lesions, and endodontically treated teeth.

Observers’ characteristics

All assessments were performed by two investigators (GD, TPGÖ) with at least five years of experience in their field in a darkened room with a radiographic illuminator to ensure the contrast enhancement of the images. The assessments were done double-blinded. In order to avoid the examiners bias at the time of collecting data, CA was first recorded on a data collection sheet and the DA scores were tabulated later on a separate sheet.

Chronological 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 with Demirjian method

The development of the seven left permanent mandibular teeth was rated on an 8-stage scale (from A to H) (Figure 1). Being associated with a stage, each tooth was converted into quantitative values through a specific table. The scores taken from the seven teeth were added up as a gender function, and the sum of dental maturity was obtained on a scale of 0 to 100. The dental maturity score of each subject was then converted to dental age by using standard tables and/or percentile curves which were given for each gender, separately (16).

| Table 1: Age distribution of the individuals. |
|---------------------------------------------|
| Age (years) | Female (n) | Male (n) | n  | %    |
|-------|----------|--------|-----|-----|
| 3 (3-3.9) | 4     | 4      | 8  | 0.5 |
| 4 (4-4.9) | 17    | 24     | 41 | 2.6 |
| 5 (5-5.9) | 33    | 48     | 81 | 5.1 |
| 6 (6-6.9) | 35    | 49     | 84 | 5.3 |
| 7 (7-7.9) | 71    | 75     | 146| 9.2 |
| 8 (8-8.9) | 85    | 96     | 181| 11.4|
| 9 (9-9.9) | 113   | 117    | 230|14.5 |
| 10 (10-10.9) | 105 | 91     | 196|12.4 |
| 11 (11-11.9) | 87  | 99     | 186|11.7 |
| 12 (12-12.9) | 82  | 84     | 166|10.5 |
| 13 (13-13.9) | 72  | 60     | 132| 8.3 |
| 14 (14-14.9) | 31  | 38     | 69 | 4.3 |
| 15 (15-15.9) | 19  | 14     | 33 | 2.1 |
| 16 (16-16.9) | 12  | 12     | 24 | 1.5 |
| 17 (17-17.9) | 8   | 2      | 10 | 0.6 |
| Total     | 774   | 813    | 1587|100.0|
An average kappa of 0.95 for the Demirjian method and of 0.94 for the Nolla method was recorded as the inter-examiner agreement scores. The intra-examiner agreement gave the kappa values of 1.00 and 0.98 (for Demirjian and Nolla, respectively) for the examiner 1 (GD) and the kappa values of 0.98 and 0.97 (for Demirjian and Nolla, respectively) for the examiner 2 (TPGÖ).

Comparison between chronological and estimated age

There was a statistically significant difference between the mean of chronological age and the mean of age estimated according to Demirjian and Nolla methods in females, while there was statistically significant difference between the mean of chronological age and age estimated by only the Demirjian method in males (Table 2). The Nolla method underestimated chronological age, while the Demirjian method overestimated it (p<0.01). The overestimation of chronological age by the Demirjian method was statistically significant for both genders (p<0.001). On the other hand, the underestimation of chronological age by the Nolla method was statistically significant for females (p<0.001) (Table 2).

The mean age differences between the chronological and estimated ages (using the Demirjian and Nolla methods) for gender and age groups are presented in Table 3. The both of methods underestimated chronological age for female, aged <15 years and male, aged <14 years (Table 3). The underestimation was statistically significant for female, while not statistically significant for male (Table 3).

The predictive capacity of the Demirjian and Nolla methods

Analysis of the simple regression had a statical significance when the sum of the seven teeth was considered as a predictor and chronological age was considered as a dependent parameter (Table 4). It was determined that the predictive capacity for total variance of chronological age was 77.4% in participants using the Nolla score and was 74.2% in the participants using the Demirjian score.

In our study, the preference of Nolla method over the Demirjian method provided a forecasting gain of 3.2% (R^2 Nolla = 0.774 - R^2 Demirjian = 0.742), for Turkish children aged 3-17 years (Table 4). The Demirjian method predicted 76.3% of total variance of chronological age for male and 71.9% for female, while the Nolla method predicted 80.3% of total variance for male and 74.8% for female. Therefore, when considering the magnitude of the regression coefficients (Table 4), we observed that both methods are able to explain a greater proportion of total variance in male than in female. Comparison of the two methods indicated that the Nolla method had greater predictive capacity than the Demirjian method, for both genders. The forecasting gains using the Nolla method were 2.9% and 4% in female and male, respectively, which indicates very low scores (Table 4). The prediction levels of the Demirjian and Nolla methods on a scale of 0 to 1 by age groups are showed in Figure 2. There was a strong correlation between the chronological age and the estimated age by original Demirjian and Nolla methods (Figure 3).
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Discussion

Recently, there has been an increasing need for fast and inexpensive methods for age determination (18). Chronological age assessment methods with the help of dental maturation follow-up have been performed by many researchers (13, 14, 19-21). However, dental age assessment methods vary according to races and geography. Although there have been studies in different regions of Turkey (Figure 4), their samples were not as large as in our study (1, 9-11, 13-15, 22, 23). In addition, there are only 3 studies comparing Demirjian and Nolla methods within the same study protocol (9, 10, 14). The aim of the present study was to evaluate the usability of Demirjian’s (16) and

| Table 2: Comparisons between the chronological and estimated (by Demirjian and Nolla methods) ages in females, males, and overall. |
| --- | --- | --- |
| Age (years) | Mean | SD |
| Chronological | 9.69 | 2.82 |
| Demirjian estimation | 10.36 | 3.28 |
| Nolla estimation | 9.53 | 3.23 |
| Comparisons | Difference between means | SE |
| Demirjian vs. Chronological | 0.68*** | 0.04 |
| Nolla vs. Chronological | -0.16*** | 0.04 |
| Demirjian vs. Nolla | 0.833*** | 0.03 |

| Table 3: Difference between means for the chronological and estimated by Demirjian and Nolla methods for ages, for genders and age groups. |
| --- | --- | --- | --- | --- |
| Age (years) | DA – CA (SD) | NA – CA (SD) | DA - CA (SD) | NA - CA (SD) |
| Females | Males |
| 3 | -0.29 (0.19) | 0.22 (0.32) | 0.24 (0.86) | 0.47 (0.67) |
| 4 | 0.23 (1.53) | 0.23 (1.36) | 0.56 (1.46) | 0.15 (0.58) |
| 5 | 0.82 (1.09)** | -0.11 (0.58) | 0.66 (1.04)*** | 0.08 (0.65) |
| 6 | 0.79 (0.67)** | -0.34 (0.76)* | 0.66 (0.89)*** | -0.26 (0.63)*** |
| 7 | 0.81 (1.44)*** | -0.43 (1.12)* | 0.73 (1.39)*** | 0.07 (1.28) |
| 8 | 0.61 (1.53)** | -0.42 (1.17)** | 0.31 (0.91)*** | -0.15 (0.94) |
| 9 | 0.58 (1.40)** | -0.45 (0.92)** | 0.43 (1.61)** | -0.26 (1.22)* |
| 10 | 0.82 (1.81)*** | -0.31 (1.68) | 0.40 (1.77)* | -0.32 (1.44)* |
| 11 | 0.91 (1.90)** | -0.68 (1.37)*** | 0.63 (1.66)*** | -0.16 (1.57) |
| 12 | 1.22 (1.77)** | -0.12 (2.18) | 1.03 (2.06)*** | 0.33 (2.11) |
| 13 | 1.02 (2.12)** | 0.18 (2.15) | 0.91 (2.20)** | 0.59 (2.01)* |
| 14 | 1.23 (2.12)*** | 0.66 (1.74)* | 1.42 (1.47)*** | 0.99 (1.43)*** |
| 15 | 0.70 (0.76)** | 0.06 (1.58) | -0.34 (2.08) | -0.37 (2.09) |
| 16 | -1.78 (2.68)* | -1.97 (2.66)* | -0.21 (0.68) | -0.42 (0.94) |
| 17 | -3.07 (2.57)* | -3.67 (2.57)** | -1.92 (0.80) | -2.32 (1.36) |
| Total | 0.75 (1.72)*** | -0.32 (1.60)*** | 0.61 (1.61)*** | -0.003 (1.45) |

CA: Chronological Age, DA: Demirjian Age, NA: Nolla Age, SD: Standard Deviation, *p<0.05, **p<0.01, ***p<0.001.
Nolla’s (17) methods for assessing the eastern Turkish population. In this study, we also emphasized and evaluated male and female differences, and age differences. This radiological dental age assessment study on a large population of people in Eastern Turkey can shed light on the age determination methods that can be applied in this region.

The age determination methods should be evaluated separately for male and female participants. Since physiological development and dental development are compatible with each other and male and female physiological development is different, individuals were divided into two groups according to gender while performing an evaluation in this study (16, 17). In this study, the mean difference between the
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CA and the dental age according to the Demirjian method ranged from -3.07 to 1.23 years (mean: 0.75) in females and -1.92 to 1.42 years (mean: 0.61) in males. Similarly, the results from other studies, used the Demirjian method, supported that the dental age assessment performed by the Demirjian method shows more value than the chronological age. These studies showed the following results (range): 0.14 to 2.79 in a Serbian population (24); -0.1 to 1.15 (0.75) years in females, -0.22 to 0.80 (mean:0.49) years in males in a South Australia population (25); 0.28 to 0.87 years in females, 0.10 to 0.76 years in males in a western Turkish population (1); 0.50 to 1.44 years in females and 0.36 to 1.43 years in males

### Table 5: Studies conducted in Turkey about age estimation by Demirjian and Nolla methods.

| Localization                  | Altitude | n     | Age (years) | Male                      | Female                     |
|-------------------------------|----------|-------|-------------|---------------------------|----------------------------|
|                               |          |       |             | The mean difference       | The mean difference         |
|                               |          |       |             | between the chronological and dental ages ranged | between the chronological and dental ages ranged |
| Demirjian                     |          |       |             | -1.92 to 1.42 years       | -3.07 to 1.23 years         |
| The present study             |          |       | 3-17.9      | 0.61 years                | 0.75 years                 |
| Altunsoy et al. (1)           | 25 m     | 635   | 7-16        | 0.10 to 0.76 years        | 0.28 to 0.87 years         |
| Tunc et al. (23)              | 4 m      | 900   | 4-12        | 0.36 to 1.43 years        | 0.50 to 1.44 years         |
| Nur et al. (14)               | 37 m     | 673   | 5-15.9      | 0.27 to 1.60 years        | 0.15 to 1.24 years         |
| Mentes et al. (22)            |          | 419   | 5-11.9      | 0.18 to 0.54 years        | -0.07 to 0.73 years        |
| Celikoglu et al. (13)         |          | 1900 m| 7-15        | 0.4 to 1.3 years          | 0.2 to 1.9 years           |
| Cantekin et al. (15)          |          | 1900 m| 7-14.9      | -0.45 to 2 years          | Central Anatolian population was dentally advanced compared with the Eastern Anatolian population. 0.91 years |
|                               |          | 1071 m| 7-14.9      | 0.70 to 3.15 years        | 0.24 to 1.28 years         |
|                               |          |       |             |                           | Central Anatolian population was dentally advanced compared with the Eastern Anatolian population. 0.81 years |
|                               |          |       |             | 0.87 years                | 0.45 years                 |
| Kirzioglu et al. (9)          |          | 1043 m| 7-13        | 0.37 to 0.68 years        | 0.34 to 1.17 years         |
| Celik et al. (11)             |          | 100 m | 4-18        | -1.02 to 1.69 years       | -1.20 to 1.36 years        |
| Nolla                         |          |       |             |                           |                           |
| The present study             |          |       | 3-17.9      | -2.32 to 0.99 years       | -3.67 to 0.66 to years     |
| Miloglu et al. (10)           |          | 1900 m| 6-18        | 0.0 to -0.6 years         | -0.1 to -1.0 years         |
| Nur et al. (14)               | 37 m     | 673   | 5-15.9      | -0.01 to -0.93 years      | -0.01 to -0.94 years       |
| Kirzioglu et al. (9)          |          | 1043 m| 7-13        | -0.54 to 0.25 years       | -0.67 to 0.27 years        |

Central Anatolian population was dentally advanced compared with the Eastern Anatolian population. 0.91 years.
in a northern Turkish population (23). In a study conducted in Saudi Arabia, the ages were overestimated by 0.3 years in males and 0.4 years in females (26). In another study from Saudi Arabia, the Saudi boys were 0.57 years, and girls were 0.44 years ahead of their chronological ages (27).

In the dental age assessment performed by the Nolla method, it was shown in the studies that it exhibits a lower value than chronological age (10, 14, 28). Miloglu et al.'s (10) study which was done in the east of Turkey by using the Nolla method, dental age was calculated 0.5 years lower in females and 0.2 years lower in males than chronological age. In another study conducted in the north of Turkey with the Nolla method, dental age was found to be 0.57 years lower in females and 0.50 years lower in males compared to the actual chronological age (14).

In a study conducted in the south of Turkey, dental age indicated an underestimation of 0.53 and 0.57 years for males and females, respectively, according to the Nolla method, and an overestimation of 0.52 and 0.75 years for males and females, respectively, according to the Demirjian method (9). Similarly, in our study, there was an overestimation of 0.61 years for males and 0.75 years for females according to the Demirjian method, while there was an underestimation of 0.32 years for females and 0.003 years for males according to the Nolla method. The dental development was more advanced in girls than in boys, and this result is consistent with others (1, 9, 13-15, 25).

The differences between the studies can be caused by climate conditions, nutrition, and socioeconomic level (29). In addition, the studies conducted in Turkey were carried out especially in geographic areas that exhibit significant altitude differences. Previous studies have also demonstrated differences between geographical areas and cities within the same country (11, 15). Turkey, affected by different climates, is surrounded by the sea on three sides and also has one of the highest altitude cities of the world, namely Erzurum. The Turkish studies are presented in Table 5, and the results show how effective geographic differences could be in tooth development. For example, Miloglu et al. (10) conducted the study in the highest altitude region of Turkey (altitude = 1900 m, which is one of the highest altitude regions in the world), Altunsoy et al.’s (1) study included participants who live at an altitude of 25 m, Nur et al. (14) at 37 m, Kirzioglu et al. (9) at 1043 m, while the present one at 970 m. Although our study was conducted in the eastern area which is similar to the Miloglu et al. (10), the altitude in that province was much lower than that of the Erzurum province. The altitude is an important parameter affecting dental development, were preferred to estimate the chronological age, considering that the results of the study could be compared.
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