

Evaluation And Comparison of The Accuracy of Nolla and Demirjian Methods for Age Estimation In a sample of Egyptian Children using Panoramic Radiographs (A Retrospective Study)

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Abstract

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Background: Age estimation is a crucial step in forensics. For living this could be valuable in civil conflicts e.g., marriage, employment, military, and recruitment. Also, it is important in criminal cases involving rape, kidnapping, and illegal immigration. In cadavers, it could help in the identification of victims of mass disasters e.g., fires, crashes. **Aim:** The current study aimed at estimating the age of a sample of Egyptian children through using both Nolla and Demirjian methods, comparing these ages with their chronological ages, generating an equation that could be used to predict chronological age in both males and females and then assessing the accuracy of these methods. **Materials & Methods:** A retrospective study on dental panoramic radiographs of 180 children aged 4-16 years. The mean dental age (DA) according to the Demirjian and Nolla methods were compared to the mean chronological age (CA). **Results:** The mean CA of the study sample was $9.90 \pm 2.71y$ and $9.40 \pm 3.23y$ for females and males, respectively. Using the Demirjian method, the mean estimated DA was 9.38 ± 2.09 years for females and 9.77 ± 3.01 years for males. For Nolla method, the mean estimated DA was 8.48 ± 1.79 and 9.07 ± 2.77 years for females and males, respectively. The mean differences between the DA and CA according to the Demirjian were $-0.52y$ and $0.37y$ for females and males, respectively. For Nolla method the mean differences were $-1.42y$ and $-0.33y$. **Conclusions:** Nolla method was found to underestimate DA in Egyptian children, while the Demirjian method tends to overestimate it. But Nolla method showed more accuracy.

Key words

Dental age, Demirjian, Nolla, Chronological age

Introduction

Age estimation is a crucial procedure in forensic identification of both living and dead persons. For living it is performed in circumstances where the birth certificate is missing, or the medical records are suspicious. This could be of value in civil conflicts e.g., marriage, employment, military recruitment, inheritance, and adoption. Also, it is important in criminal cases involving rape, kidnapping and illegal immigration, as well as for medical cases as pediatric endocrinopathy and orthodontic malocclusion (Altunsoy et al., 2015).

Age estimation of dead persons is performed in criminal conditions, as well as for identification of victims of mass disasters, such as explosions, crashes, accidents, homicides, and infanticides (Melo and Ata-Ali, 2017).

In Egypt, age determination has showed tremendous importance in certain situations like early marriage, to confirm whether a child has reached the age of criminal responsibility in cases involving rape, killing, asylum-seekers and refugees, illegal migration, children kidnapping crimes (El-Bakary, 2021).

Different methods have been developed to estimate age; these include morphological age, secondary sexual characteristics age, skeletal age, and

dental age, the latest became one of the most valid methods as it is resistant to changes by environmental and nutritional factors compared to skeletal and physical maturation (Al Balushi et al., 2018).

Several methods have been attained for estimating the dental age of an individual based on assessment of the eruption of the permanent teeth i.e. the degree of calcification is correlated with different mineralization of morphological stages that can be observed radiographically. In children and adolescents these radiographic methods are preferred (Alshihri et al., 2016).

The methods suggested by Nolla and by Demirjian et al. are two of the most approved methods for age estimation for children and adolescents (Melo and Ata-Ali, 2017).

Aim of the Study

The current study aimed at estimating the age of a sample of Egyptian children through using both Nolla and Demirjian methods, comparison of these ages with their chronological ages and then assessing the accuracy of these methods and generating an equation that could be used to predict chronological age in both males and females.

Materials and Methods

- Type of Study: Retrospective cross-sectional study.
- Study Setting: The study was conducted on children's dental panoramic radiographs (DPTs). These radiographs were obtained from the archive of oral radiology department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt from 2/2018 to 11/2019.
- Study Population: 180 panoramic radiographs of both males and females (115 males, 65 females) were chosen and divided according to the subject's ages into 6 groups (12 subgroups) with at least five participants per age group as follows presented in table (1).
- Selection criteria for the study sample

Inclusion criteria

- Availability of case records date of birth (DOB) and date of radiography (DOR).
- Egyptian children with chronological age (CA) between 4-16 years.
- Panoramic radiograph with adequate quality without any distortions.

Exclusion criteria

- Dental panoramic radiographs that showed fractures, dental anomalies, extracted permanent teeth, localized oral pathology, impacted teeth or patients using orthodontic appliances that interfere with the proceed of teeth identification.
- DPTs of patients having bilaterally missing teeth in mandible.
- DPTs of poor quality in which one or more targeted teeth could not be scored.
- Cases suffering from severe malocclusion.

Ethical Considerations:

Approval was obtained from the archive of oral radiology department, Faculty of dentistry Ain Shams University and from The Research Ethical Committee Ain Shams University (FWA00017585).

All panoramic radiographs of Egyptian cases are included in the study. No personal data were included except gender, the date of Birth (DOB) and the date of the radiograph (DOR). Other personal information of patients was kept anonymous to respect patients' confidentiality.

The DPTs were previously taken for diagnostic purposes and were reused in this study.

Study tools:

Personal information and DPT related to the chronological age CA of each subject, such as the (DOB and DOR) and sex were collected from the existing Records.

Each DPT was taken and then assigned a code, scanned at a resolution of 300 dpi in gray-scale format, and stored as a JPEG image with dimensions of 2440 × 1280 pixels (Epson scanner 1000XL, EpsonInc., USA).

The chronological ages of the participants were calculated by subtracting the DOB from the DOR and were recorded as years, months, and days.

- Scoring of the radiographs

All the DPTs were examined for scoring independently and randomly (using electronically

generated random numbers) by each of the two examiners, who was blinded to the CA but with known sex of each subject.

The digitized DPT was viewed on a widescreen monitor with Microsoft Office Picture Manager 2010 (Microsoft Corp., USA); when required, the DPT was magnified up to two times for identification of the dental development stages.

A Microsoft Excel 2010 (Microsoft Corp., USA) database was used for data entry.

DPTs were examined to evaluate the grade of mineralization of each left mandibular permanent tooth excluding the 3rd molar. According to Nolla there has been ten maturation stages. Scoring for each stage is assigned according to its number e.g., stage 5 has score 5, stage 8 has score 8 ...etc. For teeth in intermediate stages i.e. in cases when studied tooth was found to be between two stages, a value of 0.5 was added to the punctuation; In those cases when it showed development slightly above than that described by stage, 0.2 was added to assigned score (punctuation); in cases when the tooth exhibited a slightly lesser development to the following stage, 0.7 was added, then the obtained scores were added, and the result was transformed into dental age by means of tables standardized for each gender (*Nolla.,1952*)(Figure 1).

On the other hand, By Demirjian method each tooth of the left seven mandibular teeth was carefully assessed according to eight developmental stages (from A to H), then the developmental stage of each tooth was then converted into a score using the tables outlined by the Demirjian et al. method for males and females separately. These scores of each individual tooth were added together and the sum of the total scores was expressed as the dental maturity score assigned on a scale from 0 to 100 (*Demirjian et al.,1973*) (Figure 2).

Double blind examination of the DPTs was done. Sum of stages was assessed and consequently the dental age was separately determined.

The different value for each sample was then calculated by subtracting the chronological age from the dental age (positive and negative values indicated overestimation and underestimation, respectively).

Statistical analysis.

The collected data was revised, coded, tabulated in Microsoft Excel file and further analyzed statistically using Statistical package for Social Science (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

Descriptive statistics:

Mean, standard deviation (\pm SD), and range for parametric numerical data.

Analytical statistics:

- Paired t-test was used to assess the statistical significance of the difference between estimated dental age and chronological age. The level of significance was set at 5%. The difference between estimated dental age and chronologic age was

considered as age error. A negative age error indicated an underestimation of age, whereas a positive age error indicated an overestimation of age.

- Correlation analysis (Pearson's test) was used to evaluate the correlation between chronological age and dental age.

Linear regression was used to test and estimate the dependence of a quantitative variable based on its relationship with a set of independent variables.

Results

Using Nolla method for different age groups comparing between males and females: The mean differences in the CA versus estimated DA were -0.33 ± 1.30 years and -1.42 ± 1.66 years, in males and females respectively. There was a significant difference between the studied six age groups of males and females, except for the age group ($>6-8$ years) which showed no significant difference (Table 2).

Using Nolla method in males: The mean difference between the CA and DA ranged from 0.56 ± 0.87 to -1.15 ± 1.72 years. These differences were statistically significant except among the following groups: (< 6 years) and ($>14-16$ years) (Table 4).

Applying Nolla method on females: The mean difference between the CA and DA ranged from 1.04 ± 0.21 to -4.75 ± 1.96 years. These differences were statistically significant in all age groups except ($>8-10$ years). Underestimation was noticed in both sexes except the age group (less than 6 years in both) and group (male $>6-8$ years) (Table 5).

Using the Demirjian method for different age groups comparing between males and females: The mean differences between the CA and estimated DA were 0.37 ± 1.39 and -0.52 ± 1.74 years for males and

females, respectively. There was a significant difference between the studied six age groups of males and females except for the age group ($>8-10$) years and ($>12-14$) years that showed no significant difference (Table 3).

Using the Demirjian method in males: The mean difference between the CA and DA ranged from 1.06 ± 0.96 to -0.13 ± 0.85 years. These differences were significant in age groups (<6 years) and $>6-8$ years but other groups show no significant difference (Table 6).

Applying the Demirjian method on females: The mean difference between the CA and DA ranged from 1.37 ± 0.37 to -3.35 ± 2.41 years. These differences were significant in all age groups except ($>8-10$ years). Overestimation was noticed more in males in age groups (< 6 years), ($>6-8$ years), ($>8-10$ years) and age group ($>12-14$ years). while underestimation was noticed more in females in age groups more than 10 years (Table 7).

The correlation between chronological age and dental age: was assessed using (Pearson's test). It was performed for the total male and female samples according to both methods. Results showed a strong linear correlation between CA and DA for both Demirjian method ($r^2=0.86$) and Nolla method ($r^2=0.87$). (Figs. 4 and 5) show the scatter plots of DA versus CA according to Nolla and Demirjian methods, respectively.

The ability of Nolla and Demirjian methods to predict chronological age in both males and female was measured using linear regression.

Chronological age in males = $1.039 \times$ Nolla age

Chronological age in females = $1.169 \times$ Nolla age

Chronological age in males = $0.962 \times$ Demirjian age

Chronological age in females = $1.052 \times$ Demirjian age

Table (1): Number and percent of age and sex distribution among the studied Dental Panoramic Tomographs:

		N	%
Sex	Male	115	63.9%
	Female	65	36.1%
Chronological age (years)	< 6	14	7.8%
	>6-8	48	26.7%
	>8-10	40	22.2%
	>10-12	37	20.6%
	>12-14	28	15.6%
	>14-16	13	7.2%
Total		180	100%

Table (2): Paired t test showing differences between CA and estimated DA in each studied group using (Nolla method):

	Difference between Nolla age and Chronological age				t	P value
	Mean	SD	95.0% Lower CL for difference	95.0% Upper CL for difference		
Male	-0.33	1.30	-0.57	-0.09	2.73	0.01
Female	-1.42	1.66	-1.83	-1.00	6.88	<0.001
< 6 years	0.66	0.80	0.20	1.12	3.12	0.01
>6-8 years	0.13	1.22	-0.23	0.48	0.73	0.47
>8-10 years	-0.49	0.89	-0.77	-0.20	3.46	0.001
>10-12 years	-1.24	1.13	-1.61	-0.86	6.67	<0.001
>12-14 years	-1.69	1.28	-2.19	-1.19	6.99	<0.001
>14-16 years	-2.53	2.52	-4.05	-1.01	3.63	0.003

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant*

Table (3): Paired t test showing differences between CA and estimated DA in each studied group using (Demirjian method):

	Difference between Demirjian age and Chronological age				t	P value
	Mean	SD	95.0% Lower CL for difference	95.0% Upper CL for difference		
Male	0.37	1.39	0.11	0.63	2.85	0.005
Female	-0.52	1.74	-0.95	-0.09	2.40	0.02
< 6 years	1.13	0.87	0.63	1.63	4.87	<0.001
>6-8 years	0.84	0.96	0.56	1.12	6.08	<0.001
>8-10 years	0.18	1.18	-0.20	0.56	0.95	0.35
>10-12 years	-0.58	1.39	-1.04	-0.11	2.53	0.02
>12-14 years	-0.55	2.05	-1.34	0.25	1.42	0.17
>14-16 years	-1.37	2.24	-2.72	-0.01	2.20	0.05

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant*

Table (4): Paired t-test showing differences between CA and estimated DA in each studied group of 115 males using (Nolla method):

	Differences between Nolla age and Chronological age				t	P value
	Mean(y)	SD(y)	95.0% Lower CL for difference	95.0% Upper CL for difference		
Male ≤ 6 years	0.56	0.87	-0.02	1.15	2.14	0.06
Male >6-8 years	0.43	1.22	0.00	0.87	2.04	0.05
Male >8-10 years	-0.47	0.78	-0.81	-0.14	2.91	0.01*
Male >10-12 years	-0.83	0.99	-1.25	-0.41	4.11	<0.001*
Male >12-14 years	-1.16	1.40	-1.91	-0.41	3.30	0.01*
Male >14-16 years	-1.15	1.72	-2.58	0.29	1.89	0.10

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant*

Table (5): Paired t-test showing differences between CA and estimated DA in each studied group of 65 females using (Nolla method):

	Differences between Nolla age and Chronological age				t	P value
	Mean(y)	SD(y)	95.0% Lower CL for difference	95.0% Upper CL for difference		
Female ≤ 6 years	1.04	0.21	0.51	1.56	8.53	0.01*
Female >6-8 years	-0.54	0.94	-1.06	-.02	2.24	0.04*
Female >8-10 years	-0.51	1.05	-1.05	.03	2.00	0.06
Female >10-12 years	-1.98	1.00	-2.59	-1.38	7.15	<0.001*
Female >12-14 years	-2.40	0.61	-2.78	-2.01	13.73	<0.001*
Female >14-16 years	-4.75	1.96	-7.19	-2.31	5.41	0.01*

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant, Y: years*

Table (6): Paired t test showing differences between CA and estimated DA in each studied group in 115 males using (Demirjian method):

	Differences between Demirjian age and Chronological age				t	P value
	Mean(y)	SD(y)	95.0% Lower CL for difference	95.0% Upper CL for difference		
Male ≤ 6 years	1.06	0.96	0.42	1.71	3.66	0.004*
Male >6-8 years	1.02	1.04	0.65	1.39	5.63	<0.001*
Male >8-10 years	0.09	1.14	-0.40	0.58	0.37	0.72
Male >10-12 years	-00.18	1.32	-0.74	0.38	0.66	0.51
Male >12-14 years	0.03	2.19	-1.13	1.20	0.06	0.95
Male >14-16 years	-0.13	0.85	-0.84	0.58	0.42	0.68

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant, y: years*

Table (7): Paired t test showing differences between CA and estimated DA in each studied group in 65 females using (Demirjian method):

	Differences between Demirjian age and Chronological age				t	P value
	Mean(y)	SD(y)	95.0% Lower CL for difference	95.0% Upper CL for difference		
Female ≤ 6 years	1.37	0.37	0.45	2.30	6.38	0.02*
Female >6-8 years	0.45	0.62	0.11	0.80	2.83	0.01*
Female >8-10 years	0.30	1.27	-0.35	0.95	0.97	0.35
Female >10-12 years	-1.31	1.24	-2.06	-0.56	3.82	0.002*
Female >12-14 years	-1.32	1.61	-2.35	-0.30	2.85	0.02*
Female >14-16 years	-3.35	2.41	-6.34	-0.36	3.11	0.04*

*SD= Standard Deviation, CL= Confidence Level, *P< 0.05: Significant, Y:years*

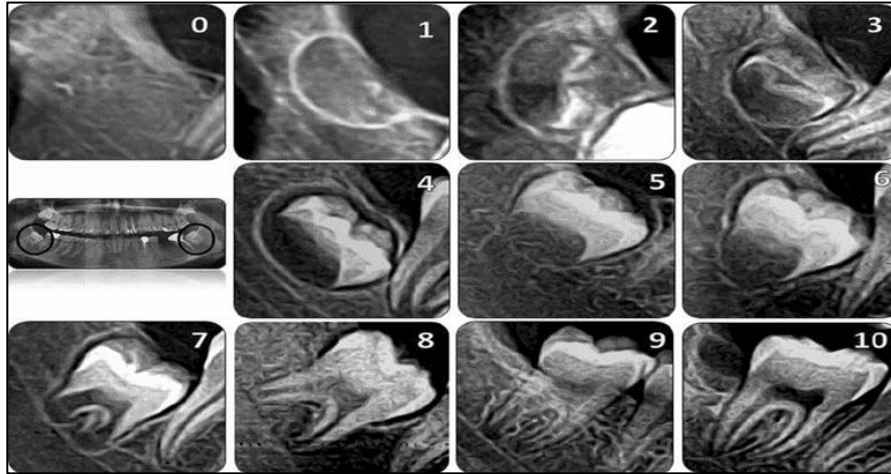


Figure (1): The 10 stages of Nolla method (Nur et al., 2012).

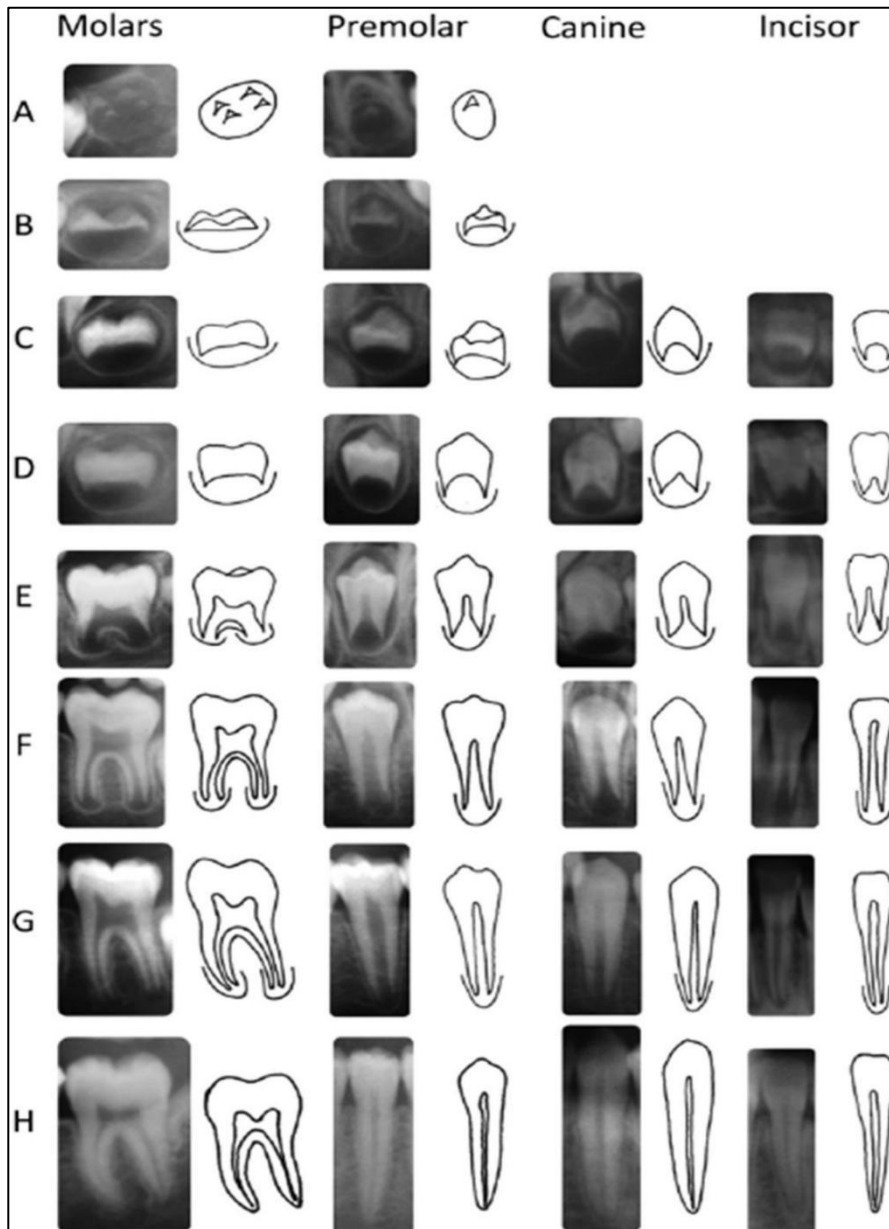


Figure (2): Developmental stages in Demirjian's method (Chinna & Chinna., 2019).

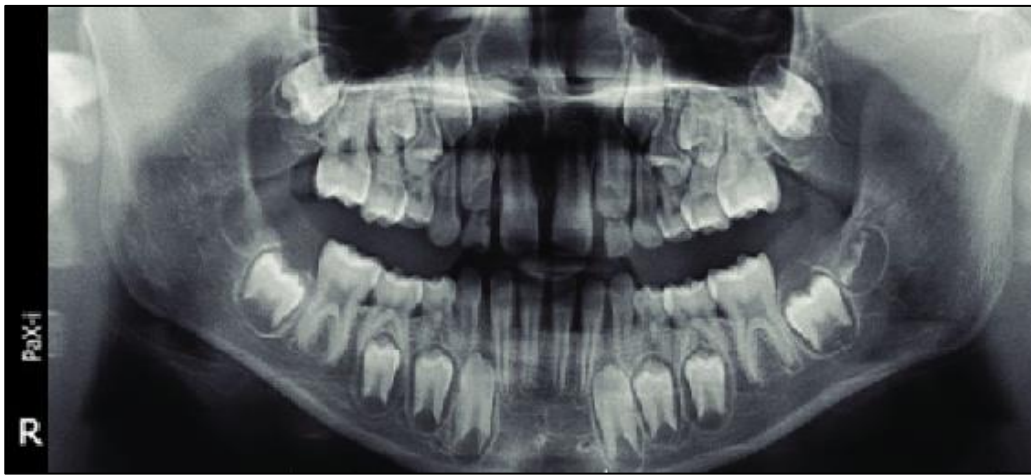


Figure (3): Panoramic X-ray film for an Egyptian male child involved in the present study. CA=8.66y. By Nolla method DA=8.86y. By Demirjian method DA=8.85y.

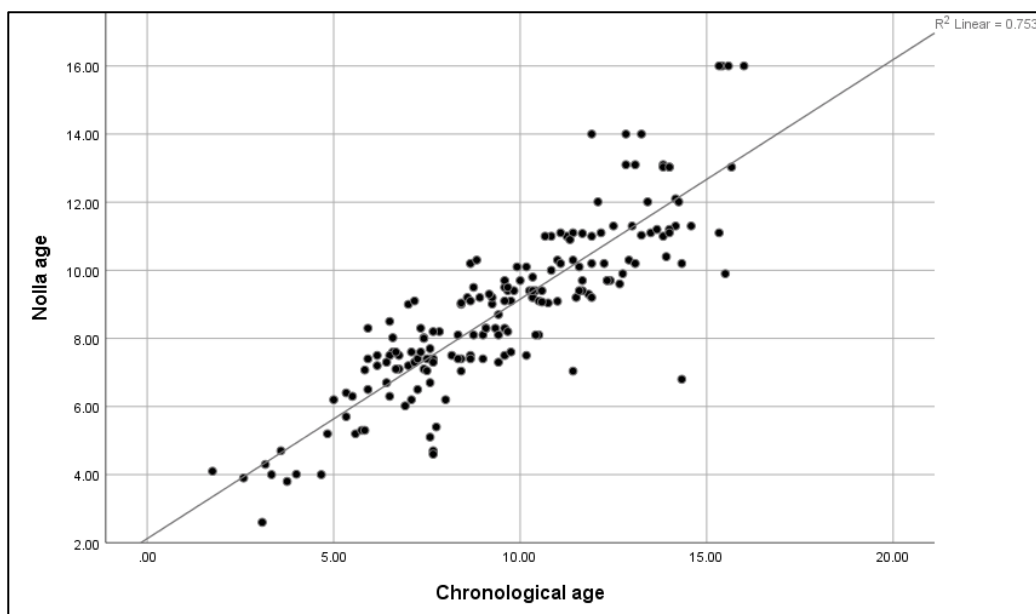


Figure (4): Scatter plot for correlation between DA and CA among the studied DPTs by Nolla method.

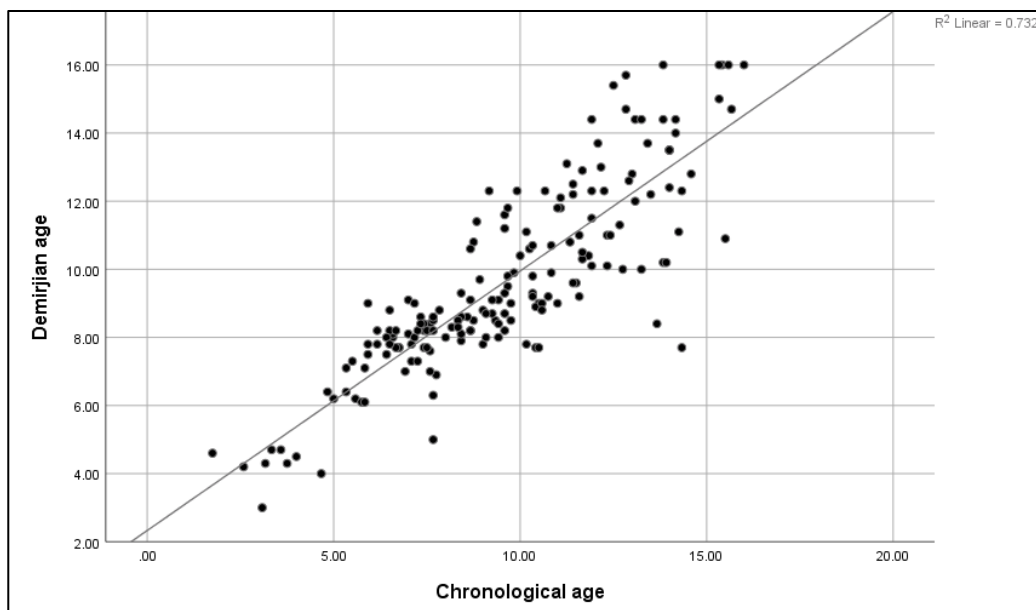


Figure (5): Scatter plot for correlation between DA and CA among the studied DPTs by Demirjian method.

Discussion

Age estimation is one of the main provocations in forensics. Determining a victim's or suspect's age accurately can help investigators focus their search and move closer to a precise conclusion (Fan et al., 2020).

Various methods with different accuracy are used for age estimation. Dental age assessment based on tooth mineralization is accepted to be more informative than gingival emergence or eruption, the reason being that tooth mineralization is primarily controlled by genes and less influenced by external factors. Among various dental age assessment methods, the radiographic technique has been proved to be more advantageous as it is simple, economical, non-mutilating, and noninvasive. Panoramic radiographs are widely preferred to assess dental maturity as it provides a distortion-free single image of the entire dentition (Yassin et al., 2020).

To determine DA there have been numerous methods. Two of these methods namely are: Nolla and Demirjian which help in both educational and clinical settings. (Lopes et al., 2018), (Cortés et al., 2019),

By using Nolla method to compare between males and females in different age groups in the present study, the average difference between dental ages and the chronological ages were in males -0.33y and in females -1.42y, and both were statistically significant.

This is consistent with Nur et al. (2012) who made a study on 673 northeastern Turkish children aged 5–15.9 years. The mean difference between the CA and DA according to the Nolla method, in this study, was -0.50y and -0.57y years for males and females, respectively.

Also, In agreement with results of Melo and Ata-Ali. (2017) who made a study on a sample of 2641 DPTs (1322 males and 1319 females) between 7–21 years among Spanish population. The mean difference between the CA and DA according to the Nolla method, in this study, was - 0.26y and - 0.16y for males and females, respectively.

Similarly, Hegde et al. (2017) who carried out a study on 1200 of Indian children aged 5-15 years in which the mean difference between CA and DA according to Nolla's method was underestimated age by -0.13y, -0.30y in boys, girls respectively.

This coincides with Tomás et al. (2014) who made another study composed of 821 DPTs of healthy 270 Portuguese and 551 Spanish subjects from 4 to 34 years old. The Nolla method tends to underestimate it.

Kırzioğlu & Ceyhan, (2012) also studied a sample of 425 Turkish children between 7 and 13 years old, from the same socio-economic class and the same ethnic group. An underestimation of -0.53y years was found for boys and -0.57y for girls with the Nolla method, this method being more accurate between 9 and 11 years in both sexes and in the group of 13-year-old girls.

However, the current results are in contrary to those obtained by Kumaresan et al. (2016) who carried out a study on 426 DPTs of 5–15 years old Malaysian children, whose results showed a general

overestimation of +0.97y. The difference could be explained by the variations between geographical areas as stated by several investigators.

It was noticed that Nolla's method predicted chronological age more accurately for males and females below 12 years age group.

Yassin et al. (2020) agrees with this finding, as they studied 458 DPTs 187 males and 271 females of 5–11 years old healthy Saudi children. The mean difference between estimated dental age and chronological age in males ranged from -2.68y to -6 months and -2.17y to -4.24y months in females.

In the current study, underestimation was noted by applying the Nolla method, this is similar to most studies conducted by Kurita et al., (2007); Miloglu et al., (2011); Kırzioğlu & Ceyhan, (2012); Nur et al., (2012); Tomás et al., (2014); Melo and Ata-Ali., (2017); and Hegde et al., (2017), where their results revealed that Nolla method underestimate the chronological age of the studied groups. In contrast, overestimation was observed in a study done by Mohammed et al. (2015), who examined 660 DPTs of South Indian children between the ages of 6 and 16 years and found significant overestimation of +0.31y and +0.63y in males and females respectively. Of all the methods employed, the Nolla method was the most accurate.

Also, Kumaresan et al. (2016) conducted a study on Malaysian children whose results showed a general overestimation of +0.97y. Lopes et al. (2018) performed a study on 403 healthy Brazilian children between the ages of 7 and 13 years, his study showed no significant difference in relation to chronological age in the majority of age groups for boys and girls, except for 12-year-old boys (over-estimation of 1.00y) and between 11- and 12-year-old girls (over-estimation of 0.51y and 0.59y, respectively). These discrepancies may be owed to different ethnicities of their study sample.

On comparing the predicting ability of Nolla method as regards the age of males and females, it was noticed that the dental age of children significantly underestimated the chronological age by (-.47y, -1.15y) in males and (-.54y, -4.75y) in females (p value > 0.005). This indicates that the calculated dental age of males showed closer value to Nolla's age estimation than that of females. It is supported by a study which was done by Hegde et al., (2017) in males and females and showed differences (0.13y- 0.80y and 0.30y- 0.82y, respectively).

On the contrary, in a validation study performed by Nur et al., (2012), using Nolla's and Demirjian's method on Turkish children, they reported that the mean difference between chronological age and dental age in females was 0.15y–1.24y, whereas it was 0.27y–1.60y in males. Khoja et al., (2015) in their study on 8–17 years old Pakistani orthodontic patients using Nolla's method, observed an advanced dental maturity of $0.21y \pm 1.64$ in females, whereas a delayed dental maturity of -1.00 ± 1.54 years in males.

The possible cause for the underestimation of chronological age by Nolla's method may be due to the added number of stages. The method helps the observer to select between the ten stages with a supplementary three interstage options for each stage, reaching a total of 40 stages. Expanding the number of stages is reported to decrease the accuracy of the method (Yassin et al., 2020). The variation between ethnic groups is a vital factor and is supported by recent findings of differences in tooth formation. The other reason could be the genetic and environmental influences affecting biological growth of teeth among populations. Hence chances of misrepresentation of health status and growth data could occur if the standard used for one population is applied to another (Esan et al., 2017).

By applying Demirjian method, in this study on both sex groups, it was observed that there was an initial overestimation of age groups less than 10 years, then underestimation in groups more than 10 years. These results agreed with Aissaoui et al. (2016) who studied 280 healthy Tunisian children of age 2.8–16.5 years using Demirjian method, Underestimation was seen in children aged between 9 and 16 years and the range of accuracy varied from $-0.02y$ to $3y$. The advancement in dental age as determined by Demirjian system when compared to chronological age ranged from $0.3y$ to $1.32y$ year for young males and from $0.26y$ to $1.37y$ year for young females (age ranged from 3 to 8 years). Also, this coincides with Alhaija et al. (2020) who conducted a study on 1374 Caucasian Jordanian children (684 females and 690 males) aged 4 to 16 years found Demirjian method overestimated chronological age in female and male subjects aged 4 to 8 years. Afterwards, the method underestimated chronological age in females aged 9–11 years and 14–16 years. In male subjects, chronological age was underestimated in subjects aged 9–12 years and 15–16 years.

On the other hand, overestimation was found in both sexes and all age groups in a study of 400 Egyptian children aged 5–13 years (Azzawi et al., 2016). This could be attributed to the socioeconomic status, nutrition and dietary habits that may affect the results (Aissaoui et al., 2016). Another study of 2000 northern Chinese children (1000 boys and 1000 girls) with an age range between 5 and 14 years. The Demirjian method overestimated chronological age in both sexes and all age groups (Han et al., 2020).

The current study revealed a mean overestimation of 0.37 years in the male group, while in the female group, the mean difference between the DAs and CAs was underestimated by -0.52 years. This agrees with a study of 1902 DPTs of Saudi children (955 boys and 947 girls) between the ages of 3 and 17 years that found overestimation in male groups and underestimation in girls in some groups (Al-Dharrab et al., 2017).

Of 635 Western Turkish children aged 7–16 years found overestimation in both sexes by 0.10–0.76 years in males and 0.28–0.87 years in females (Altunsoy et al., 2015). Similar findings were reported

in a study conducted on Spanish and Venezuelan children by Cruz-Landeira et al. (2010), who examined 308 Spanish Caucasian and 200 Venezuelan Amerindian children, aged between 2 and 18 years. In the Venezuelan Amerindian sample, Demirjian's method overestimates the age in the Spanish Caucasian sample by 0.76 ± 1.01 years for boys and 0.88 ± 1.09 for girls, while underestimates it in the Venezuelan sample by -0.23 ± 0.93 years for boys and -0.1 ± 1.04 years for girls, respectively.

In contrast to the current results, Han et al. (2020) found that Demirjian method overestimated chronological age in both sexes by 1.17 ± 0.03 years for boys and 1.15 ± 0.03 years for girls. Another study of 660 DPTs was done on South Indian children between the ages of 6 and 16 years and found underestimation of -0.23 years in boys and overestimation by 0.43 years in (Mohammed et al., 2015).

The differences in age estimation between the current study and those of other studies could be explained by the differences in sample size, age groups, and studied populations. Other factors, such as socioeconomic status, nutrition, and dietary habits, may also affect the outcomes (Aissaoui et al., 2016).

In the current study, the mean difference between the dental age and chronological age ranged from $1.37y$ to $-3.35y$ in females and from $1.06y$ to $-0.13y$ in males. This implies that the observed dental age of males remained closer to Demirjian age estimation than females although it was statistically insignificant. These results are in concordance with Alhaija et al. (2020), where the mean differences between the chronological and dental ages varied from -1.22 to 1.52 years in females and from -1.65 to 1 year in males. They also agree with a study of 519 Iranian children 264 boy 255 girls aged 3.5–13.5, where overestimation was more common in younger age than underestimation in older groups, especially in male groups with mean differences 0.15 and 0.21 in males and females respectively (Bagherian and Sadeghi, 2011).

In males, the Demirjian method was more accurate between 6 and 16 years and in girls between 6 and 10 years, after 10 years the difference became great. However, no statistically significant differences were found in girls of age groups 8–10 years and in boys of all age groups more than 8 years. This may be explained by the smaller size of sample or the suitability of Demirjian method in these age groups.

The results of the current study revealed that dental maturation was more advanced in the examined females than in the studied males (mean differences between DAs and CAs of 0.37 and 0.52 years (about 6 months) for males and females, respectively). The sexual dimorphism of the acceleration of dental maturation estimated by Demirjian's method differed in numerous studies (Esan et al., 2017). This agrees with Azzawi et al., (2016), Aissaoui et al., (2016) and Mohammed et al., (2015), as they concluded that Demirjian's method was more accurate in males.

However, the DA among males could be in advance of that in females, as reported by Duangto et al., (2016) who examined a sample of Thai population and found mean differences of 0.11y and 0.10y for males and females, respectively. In addition, Gungor et al. (2015) evaluated the applicability of Demirjian's method for an elderly southern Turkish population and reported that the mean differences between the chronological and DAs ranged from 0.04y to 0.85y and from 0.02y to 0.79y in males and females, respectively. Girls indicated more advanced dental development in almost all age groups and reached dental age maturation earlier than boys. This finding was in accordance with earlier maturation of other parameters of development in girls, such as height, sexual maturation, and skeletal age. But, the actual effect of hormones on tooth development is still largely unknown (Aissaoui et al., 2016).

The application of both methods of Demirjian and Nolla in the same study had not been carried out in Egypt. Other studies examined the two methods: Hegde et al., (2017) worked on 200 radiographs in children with age range (5 to 15 years), Maber et al., (2006) analyzed 946 radiographs of children with age range (3 to 16.9 years); they found that Demirjian method overestimated the chronological age, while the Nolla method underestimated it. In other study by Mohammed et al., (2015) that analyzed 760 radiographs of children aged (6 to 16 years), and the results highlighted an overestimation by the Demirjian method. However, unlike our findings, overestimation was found with the Nolla method.

It was found that Nolla's method is more precise in age estimation in most of the studies, (Rai, 2008; Kumaresan et al., 2016; Mohammed et al., 2015) while contrasting results were seen in some other studies by Maber et al., (2006) as well. In contrary to the current study, Demirjian's method was found to be more informative when compared to Nolla's method in children of North India because of its usability to all the age groups, while Nolla's method had limited application in the younger age group (Singh et al., 2020).

It's important to acknowledge that no age estimation method can predict the exact age of every individual. Forensic science uses age ranges when estimating age for just this reason although differences between chronological and estimated ages of up to 12 months can be considered to be within normal standards smaller intervals are desirable (Hegde et al., 2017).

Conclusion

The current study concluded that there was an underestimation of the dental age by Nolla's method compared to the chronological age for both boys and girls. While in Demirjian's method there was underestimation in females and overestimation in males. Nolla method was found to be more accurate.

Further studies are required with larger number of samples, Transformation of the maturity score into DA for the Egyptian children by introduction of adaptable conversion tables could be an appropriate

substitute. The validity of the prediction equation could be tested among greater number of Egyptian children sample.

Chronological age in males = 1.039 * Nolla age

Chronological age in females = 1.169* Nolla age

Chronological age in males = 0.962* Demirjian age

Chronological age in females = 1.052* Demirjian age

Recommendations

- Further studies for both Nolla and Demirjian methods are needed using multiethnic samples to confirm their applicability.
- Further studies on Egyptian population are required with a larger representative sample tailored for the population specific standards, as they might exhibit different ethnic environmental, social and financial circumstances.
- The validity of the newly developed prediction equation must be tested among more Egyptian children in different governments.

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تقييم ومقارنة دقة طريقتي نوال ود ديمرجيان في تقدير العمر في عينة من الاطفال المصريين باستخدام صور الاشعة البانورامية (دراسة مرجعية)

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الملخص العربي

المقدمة: تقدير العمر هو خطوة حاسمة في الطب الشرعي حيث يمكن أن يكون مفيداً في بعض المواقف المتنازع عليها مثل الزواج والتوظيف والجيش والتجنيد. كما أنه مهم في القضايا الجنائية مثل قضايا الاغتصاب والاختطاف والهجرة غير الشرعية. وكذلك في حالات الجثث يمكن أن يساعد في التعرف على ضحايا الكوارث الجماعية مثل الحرائق والحوادث وقتل الاجنة.

هدف الرسالة: لقد هدفت الدراسة الحالية إلى تقييم طريقتي نولا وديمرجيان في تقدير عمر عينة من الأطفال المصريين من خلال مقارنة الأعمار عن طريق الأسنان بأعمارهم الحقيقية و انشاء معادلة يمكن استخدامها للتنبؤ بالعمر عند الذكور والإناث ومن ثم تقييم دقة هذه الأساليب.

الطرق المستخدمة: دراسة بأثر رجعي على الصور الشعاعية البانورامية للأسنان حيث قمنا بفحص ١٨٠ صورة شعاعية بانورامية لأطفال أصحاء من كلا الجنسين ، تتراوح أعمارهم بين (أقل من او تساوي ٦ سنوات _١٦ سنة). من بينهم (١١٥ ذكور و ٦٥ إناث) ، ومقسمة حسب أعمار الأشخاص إلى ٦ مجموعات : المجموعة الاولى اقل من او يساوي ٦ سنوات ، المجموعة الثانية أكبر من ٦_٨ سنوات ، المجموعة الثالثة أكبر من ٨-١٠ سنوات ، المجموعة الرابعة أكبر من ١٠-١٢ سنة (، المجموعة الخامسة أكبر من ١٢-١٤ سنة والمجموعة السادسة أكبر من ١٤-١٦ سنة

النتائج : متوسط العمر الحقيقي في عينة الاطفال التي تم فحصها كان 2.71 ± 9.90 سنة في الذكور و 3.23 ± 9.40 سنة في الاناث ، وباستخدام طريقة نولا وجد ان متوسط العمر عن طريق الاسنان 2.77 ± 9.02 في الذكور و 1.79 ± 8.48 في الاناث ، وبطريقة ديمرجيان وجد ان هذا المتوسط 3.01 ± 9.77 في الذكور و 2.09 ± 9.38 في الاناث.

كان متوسط الفروق بين العمر عن طريق الاسنان والعمر الحقيقي وفقاً لطريقة ديمرجيان هي -0.52 سنة و 0.37 سنة للإناث والذكور على التوالي. بالنسبة لطريقة نولا كان متوسط الفروق -1.42 سنة و -0.33 سنة.

الاستنتاجات: وجد أن طريقة نولا تقلل من تقدير العمر عن طريق الاسنان عند الأطفال المصريين، بينما تميل طريقة ديمرجيان إلى المبالغة في تقديره. لكن طريقة نولا أظهرت دقة أكبر.

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