
Estimation of the Chronological Age by Demirjian's Method Among Children in Cotonou

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To cite this article:

Cedric Egnonwa Bigot, Sonia Bignon Adjadohoun, David Djossou, Nicole Enianloko-Tchiakpe, Sylvie Arlette Bancole Pognon, Savi de Tove Koffi-Mensa. Estimation of the Chronological Age by Demirjian's Method Among Children in Cotonou. *International Journal of Medical Imaging*. Vol. 10, No. 1, 2022, pp. 5-9. doi: 10.11648/j.ijmi.20221001.12

Received: January 17, 2022; **Accepted:** February 18, 2022; **Published:** February 28, 2022

Abstract: In Benin, violations of child rights are common. Age estimation is a question referred for a preliminary ruling before the courts which have jurisdiction over major offenses and crimes committed against children's rights. The age estimation methods based on dental maturity and development are widely used. However, they require local validation. This research work aimed to test the applicability of Demirjian's standards among children living in the city of Cotonou. This study uses a randomized sample of 563 orthopantomograms of children aged 3 to 17 years performed in Cotonou. Dental age has been estimated based on Demirjian's standards. The reproducibility and repeatability of the method have been assessed. The differences between civil age and dental age as well as their correlation were tested. We noticed good repeatability ($Kappa=0.89$) and good reproducibility ($Kappa=0.85$) of the method. In boys of all age groups, the average difference between civil age and dental age was estimated at 0.68 years (CI95%; -0.87 to -0.49); among girls, that difference was estimated at 1.07 years (CI95%; 0.83 to 1.32). The correlation between dental age and civil age was high ($R=0.89$). A linear regression equation has been established to address the overestimation gap. According to our findings the Demirjian method may be used in Cotonou in a forensic context with one correction factor.

Keywords: Dental Age, Demirjian's Method, Children, Dental Maturity, Forensic Odontology

1. Introduction

The estimation of age in expectation of identification of a dead or disappeared individual is a frequent assignment in forensic medicine, particularly when justice suspects a crime or an accident [1]. In recent years, there has been a huge rise in the number of those assignments, and this, because of increased natural disasters, conflicts and migration flow. In Europe, forensic medicine units are regularly requested to identify bodies of migrants dead in the Mediterranean waters [2, 3]. The request related to age estimation applies not only to corpses; they are also related to living people [4]. The border

or immigration offices must take care of thousands of African migrants who arrive at borders without administrative birth documents likely to help them justify their age.

In Benin, age estimation is also a major concern in forensic medicine.

The mortuary of the University Teaching Hospital of the city of Cotonou records every year around one hundred corpses of unidentified people [5]. In 2013 around 34% of Benin citizens had no birth certificate [6]. Hence, this situation has led the Government to set up a project to enable the issuance of surrogate certificates by the courts. The courts of Benin are also faced with the child labor issue and age

fraud in sport. Age determination in a judicial context must be based on objective methods. The age estimation method proposed by Demirjian *et al.* [7] is one of the most widely used around the world [8, 9]. The inter-ethnic variations observed during dental development between different populations justify the evaluation at the local level of this method initially developed using a sample of Caucasian subjects from Canada [10-13].

It is in this context that we initiated this study that aimed to assess the applicability of Demirjian's age estimation method to the population of Benin.

2. Methods

We carried out this cross-sectional study in the city of Cotonou. Panoramic dental radiographs were collected in 2 dental practices of the city of Cotonou. Those medical practices specialized in dentistry were provided with digital imaging equipment. The panoramic dental radiographs were the ones of children aged 3 to 17 years; they were retrieved from the children's dental records. To be eligible, their dentition should have been assessed as healthy by the dentist who has been following them up. This study has not included the panoramic dental radiographs of children with a medical history that could affect their growth (history of malnutrition, endocrine disorder), dental anomalies, history of craniofacial trauma, and orthodontic treatment.

The panoramic dental radiographs then collected were examined to ensure the quality of the radiographic images. The radiographs showing congenital absence of a tooth or picture distortion in the incisor region were excluded.

Each of the 2 incisors (I1, I2), the only canine tooth (C), each of the 2 premolar teeth (PM1, PM2) and each of the 2 molar teeth (M1, M2) located on the left side of the mandible have been examined and a rate from A to H was assigned to each of those teeth depending on the criteria specifying the stages of calcification defined by Demirjian in 1973 [7].

Then, each rate, depending on the sex of the subject, was converted into scores, the sum of which helped estimate the subject's dental age.

A first operator handled the implementation of ratings. Three months after the first review, 50 orthopantomograms randomly selected were reviewed again by the first operator and then by a second operator. Those additional reviews helped calculate Cohen's Kappa coefficients. The calculation of Kappa coefficient helped measure the inter-rater and intra-rater reliability of the rating of each of the teeth in interest.

The chronological or civil age has been calculated taking the difference between the birthdate and the date of implementation of the panoramic dental radiographs.

The data collected have been encoded in an Excel spreadsheet, and then processed using SPSS 20.0 statistical program (SPSS, inc., Chicago, IL.). The p-value was considered statistically significant when it was lower than 0.05.

Statistical tests for the comparison of matched series were used to analyze the gap existing between calculated civil age and estimated dental age using Demirjian's method.

This research work has been authorized by the Ethics Committee of the Faculty of Health Sciences of Cotonou. The study of panoramic dental radiographs and the data statistical analysis were conducted on anonymity.

3. Results

3.1. Study Target Population

Within the framework of this study, 563 panoramic dental radiographs of Benin children from both sexes, and aged 3 to 17 years, have been performed and analyzed. Table 1 shows the distribution of children according to civil age and sex. Boys accounted for 52.8% of the overall population of subjects. In the boys' group, the mean civil age was 10.3 years (Standard deviation=3.92). In the girls' group, it was estimated at 9.8 years (Standard deviation =3.6).

Table 1. Age group by gender.

Age group (year)	Boys		Girls		Both	
	N	%	N	%	N	%
3,0- 3,99	17	5,72	10	3,76	27	4,80
4,0- 4,99	15	5,05	15	5,64	30	5,33
5,0- 5,99	20	6,73	24	9,02	44	7,82
6,0- 6,99	19	6,40	20	7,52	39	6,93
7,0- 7,99	23	7,74	22	8,27	45	7,99
8,0- 8,99	24	8,08	20	7,52	44	7,82
9,0- 9,99	16	5,39	22	8,27	38	6,75
10,0- 10,99	24	8,08	25	9,40	49	8,70
11,0- 11,99	21	7,07	23	8,65	44	7,82
12,0- 12,99	34	11,45	26	9,77	60	10,66
13,0- 13,99	20	6,73	17	6,39	37	6,57
14,0- 14,99	20	6,73	18	6,77	38	6,75
15,0- 15,99	21	7,07	15	5,64	36	6,39
16,0- 16,99	14	4,71	9	3,38	23	4,09
17,0-17,99	9	3,03	0	0,00	9	1,60
Total	297	100,00	266	100,00	563	100,00

N: effective; %: frequency.

3.2. Intra and Inter-observer Reproducibility of Rating

All the Cohen's Kappa coefficients (Table 2) calculated to assess the intra and inter-observer details of the rating of each of the 7 teeth located on the left side of the mandible had a

value higher than 0.80. When there was a discrepancy or inconsistency, the ratings differed by only one stage. The ratings done may be considered as being low and reproducible.

Table 2. Comparison of Demirjian's mineralization stages for intra-observer repeatability and inter-observer reproductibility.

	M2	M1	PM2	PM1	C	I2	I1
Repeatability	0.96	0.86	0.92	0.90	0.84	0.88	0.88
Reproductibility	0.90	0.82	0.80	0.84	0.86	0.84	0.88

3.3. Age Estimation with Demirjian's Method

Among the boys, the difference between the age estimated based on Demirjian's standards and the actual or chronological age (civil age) was estimated at 1.01 years (CI95%; 0.89 to 1.12) i.e. nearly 12 months (Table 3).

Table 3. Difference between chronological ages and dental ages calculated using Demirjian's method, by gender.

Age group (year)	Chronological age (AC)		Dental age (DA)		DA-AC		p-value*
	Mean	SD	Mean	SD	Mean	SD	
Boys							
3.0- 3.9	3.52	0.21	4.54	0.41	1.02	0.49	0.001
4.0- 4.9	4.43	0.26	5.54	0.73	1.11	0.63	0.001
5.0- 5.9	5.44	0.37	6.61	0.71	1.17	0.69	0.001
6.0- 6.9	6.39	0.28	7.61	0.77	1.22	0.69	0.001
7.0- 7.9	7.41	0.23	8.53	0.73	1.13	0.84	0.001
8.0- 8.9	8.58	0.28	9.82	0.85	1.24	0.88	0.001
9.0- 9.9	9.33	0.30	10.79	0.89	1.46	0.79	0.001
10.0- 10.9	10.48	0.26	11.31	1.06	0.83	0.93	0.005
11.0- 11.9	10.57	0.24	12.60	1.58	1.03	1.48	0.001
12.0- 12.9	12.44	0.28	14.03	1.05	1.59	1.08	0.001
13.0- 13.9	13.52	0.30	14.74	0.69	1.22	0.77	0.001
14.0- 14.9	14.48	0.28	15.81	0.32	1.33	0.34	0.001
15.0- 15.9	15.32	0.24	15.91	0.19	0.60	0.29	0.001
16.0- 16.9	16.58	0.28	15.99	0.53	-0.59	0.29	0.001
17.0- 17.9	17.34	0.23	16.00	0.10	-1.34	0.23	0.001
Total	10.33	3.96	11.33	3.80	1.01	1.00	0.001
Girl							
3.0- 3.9	3.45	0.26	4.16	0.59	0.72	0.62	0.005
4.0- 4.9	4.35	0.22	5.09	0.66	0.74	0.65	0.001
5.0- 5.9	5.36	0.28	6.18	0.70	0.82	0.77	0.000
6.0- 6.9	6.5	0.28	7.54	0.98	1.04	1.09	0.000
7.0- 7.9	7.43	0.23	8.52	1.09	1.09	1.09	0.000
8.0- 8.9	8.46	0.30	9.79	1.19	1.33	1.17	0.000
9.0- 9.9	9.68	0.19	11.12	1.16	1.45	1.11	0.000
1.0- 10.9	10.43	0.25	11.52	1.26	1.08	1.35	0.001
11.0- 11.9	11.39	0.31	12.77	1.30	1.38	1.40	0.000
12.0- 12.9	12.35	0.24	13.33	1.46	0.98	1.51	0.003
13.0- 13.9	13.52	0.29	14.72	1.14	1.20	1.11	0.000
14.0- 14.9	14.49	0.40	15.12	0.98	0.63	0.96	0.013
15.0- 15.9	15.33	0.30	15.61	0.57	0.29	0.61	0.880
16.0- 16.9	16.63	0.15	15.57	0.56	-1.06	0.60	0.023
17.0- 17.9	-	-	-	-	-	-	-
Total	9.84	3.62	10.79	3.64	0.94	1.18	0.000

AD: estimated Age using Demirjian's method; SD: standard deviation; *: paired t-test.

As far as girls are concerned, that difference was estimated at 0.95 years (CI95%; 0.80 to 1.09) i.e. around 11 months.

In both groups, we found a trend toward age overestimation with Demirjian's method. That overestimation is stable from 3 to 15 both in boys and girls.

The age obtained with Demirjian's method is higher than the actual age by more than one year (12 months). The gap

between AC and DA is higher than 12 months in 52% of cases.

Nevertheless, there is a high correlation between civil age and age estimated using Demirjian's method ($R=0.89$). We established a linear regression equation ($y=ax+b$) that helps determine civil age based on dental age estimated using Demirjian's method. The values of the constants a and b were determined separately for boys and girls (Figures 1 and 2).

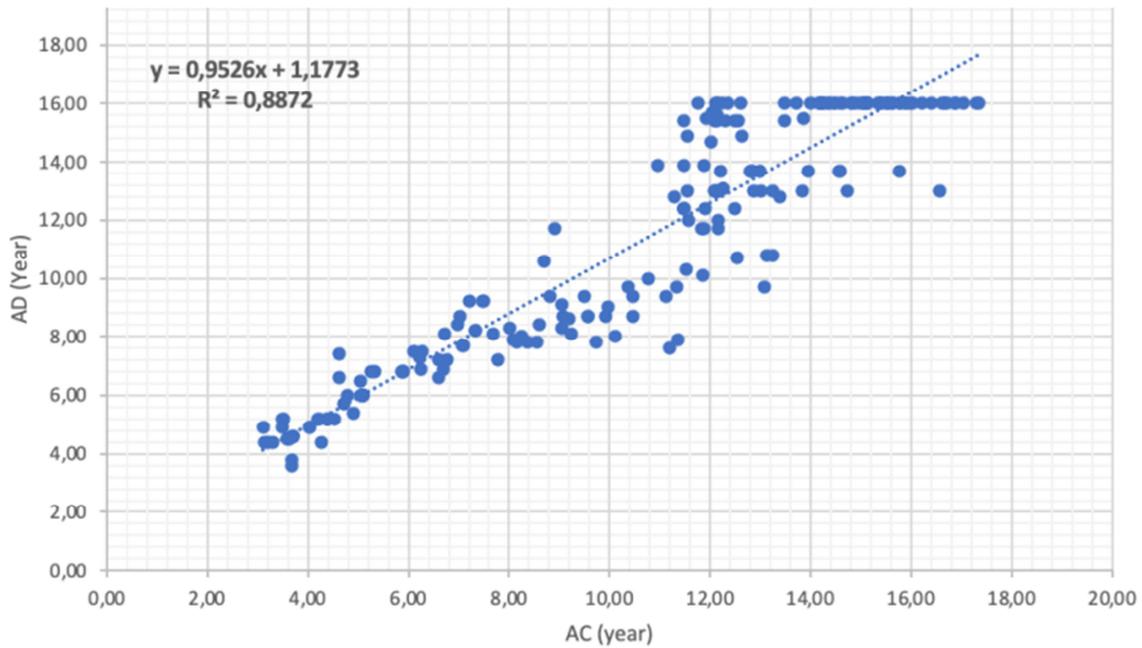


Figure 1. Chronological age against dental age through the method of Demirjian for boys and linear regression.

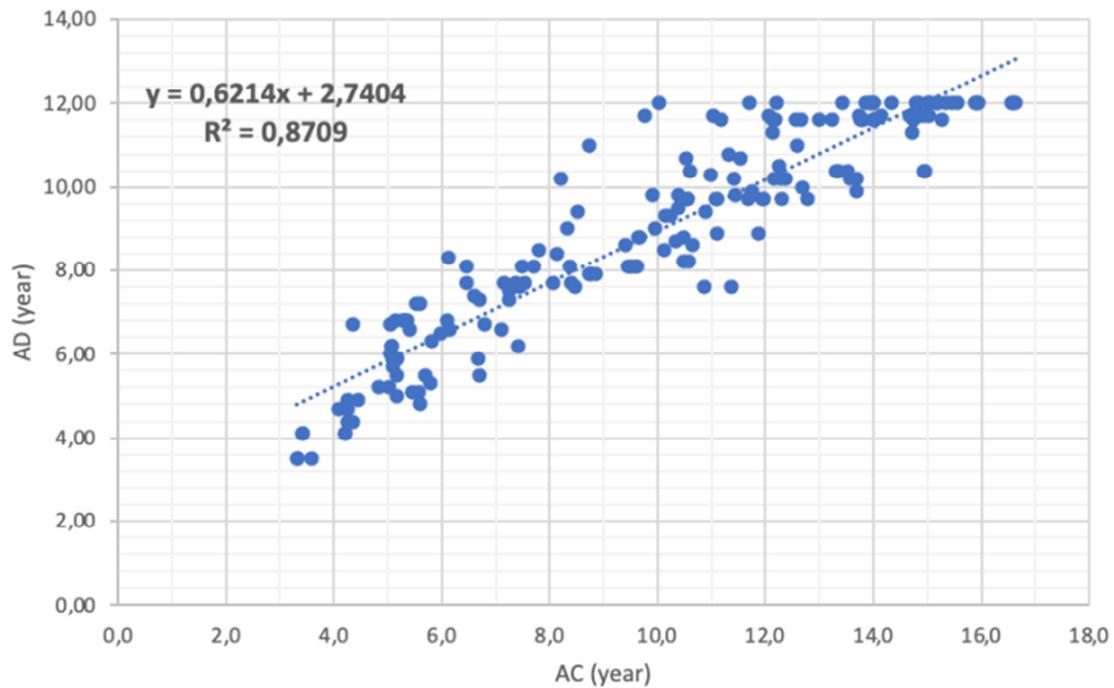


Figure 2. Chronological age against dental age through the method of Demirjian for girls and linear regression.

4. Discussion

This study aimed to assess the relevance and appropriateness of the use of the age estimation method proposed by Demirjian *et al* among Benin population. Our findings suggest that the method is reproducible but specifically there is a high association between chronological age and dental age. However, sometimes substantial disparities are noted in some groups; this is a limitation to the

accuracy of the method.

The intra and inter-observer details of tooth rating were all higher than 0.80 and there were discrepancies only about close or similar ratings. These findings show that the method is very reproducible. Demirjian's method is based on the observation of teeth which are compared to schematic representations of each of the stages of tooth mineralization. It is considered as a good method since environmental factors have little effect on tooth mineralization [13]. This reproducibility of the method is likely to reassure and put at

ease the magistrates since it reduces risks for large disparities between expertise and counter-assessment.

Our data suggest that in both sexes, there is a good correlation between actual/chronological age and age estimated using Demirjian's method [14]. All the studies agree that this correlation is an obvious reality [15]. The differences existing between the studies are more related to accuracy of the method i.e. its ability to give the age that is as close as possible to chronological age or civil age. In our sample, we noted a systematic increase in subjects' age by applying the method. That increase was estimated at nearly 12 months in boys versus 11 months in girls. Studies conducted among other black populations have reported that trend toward overestimating age. This was specifically the case in Cote d'Ivoire [16], in Senegal [17], and among other populations. In contrast, in other ethnic groups, the method led to an underestimation of age. This is the case in Switzerland [15]. Dharmo et al. had reported a relationship between the speed of tooth mineralization and genetic heritage. For instance, among populations with Black African and Asian origin, there was some acceleration of the dental maturation and development compared to the one observed among Caucasian populations in Europe [18].

5. Conclusion

Our findings, confirm that there is a high relationship between civil age and dental age. Demirjian's method may reasonably be used in the forensic context of Cotonou city. It will be necessary to take into account a correction factor of 1 year. A larger sampling will enable us to refine the results. Data collection should be extend to national level.

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