

ASSESSMENT OF THE AGE OF MAJORITY USING DEMIRJIAN MINERALIZATION STAGES AMONG A SAMPLE OF THE EGYPTIAN POPULATION

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ABSTRACT

Background and objectives: Determination of the age of majority is a major problem in forensics. This study aimed to evaluate the usefulness of Demirjian's stages of teeth development in estimating the age of majority from the left mandibular molar among a sample of the Egyptian population

Methods: A prospective cross-sectional study included a sample of 134 digital panoramic radiographs of participants aged 15-26 years. The left lower third molars were analyzed using Navegatum DICOM viewer software for the medical sector. e version 1.10.0.0 applicable on Microsoft. The effectiveness of Demirjian's stages was assessed by using accuracy, sensitivity, specificity, positive (LR+) and negative (LR-) likelihood ratios, and positive and negative predictive values

Results: The test showed better specificity for stage H (90.91% for males, and 63.64% for females), and better sensitivity for stage G (98% for males, and 95.16% for females) for adult age. The accuracy of the test was (85.25% for males and 72.60% for females) in stage H, and (93.44% for males and 87.67% for females) in stage G.

Conclusion: Demirjian's stages G and H are fairly reliable method for estimating the age of majority among Egyptians.

KEY WORDS: Age of majority; Demirjian's stages; Egyptians; Left mandibular third molar.

INTRODUCTION

In forensic practice, determination of the majority age of individuals is a pivotal issue (**Lizarbe et al. 2017**). The majority age represented when a person has considered an adult, having all rights and

adulthood responsibilities . This age varies between different jurisdictions (www.parentcenterhub.org/age-of-majority/).

In Egypt, the majority age is eighteen years , it represents a critical cut-off age; the minimum legal marriage age for males and females, age of consent

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(<https://www.ageofconsent.net/world/egypt>), driving license (<http://www.adcidl.com/Driving-in-Egypt.html>) and voting in elections (<http://www.egypttoday.com/Article/2/39736/Overview-of-voting-rights-in-Egypt>).

The Study Group on Forensic Age Diagnostics (AGFAD) recommendations for determining the age of criminal responsibility included physical and dental examination together with an X-ray examination of the left hand (**Schmeling et al. 2008**).

The third molars represent the only teeth still in development in adolescents and young adults whose dental maturation has almost complete (**Lizarbe et al. 2017**), and also the most common visible teeth from crypt appearance to apex completion on children and young adults' radiographs (**Sharma et al. 2017**).

In 1973, a new classification of tooth mineralization stages was released by Demirjian et al (**Demirjian et al. 1973**). Mincer et al. were the first to use Demirjian's mineralization stages to assess the third molars reliability in distinguishing adults from minors in 823 Americans. Their results showed that 90% of males and 92% of females with third molars in Demirjian's stage H were more than 18 years old (**Mincer et al. 1993**). In 2014, Costa et al. used the G and H developmental stages of Demirjian to determine the adult age among Mexicans and Columbians (**Costa et al. 2014**).

Currently, there is no evidence of the usefulness of Demirjian mineralization stages in estimating the majority age among Egyptians. Therefore the aim of this study was to detect the usefulness of the root development stages of Demirjian in discriminating adults and minors among a sample of the Egyptian population.

MATERIALS AND METHODS

Study population

The sample consisted of 134 (73 females and 61 males) digital panoramic radiographs

(OPTs) of patients aged between 15 and 26 years. The inclusion criteria included subjects with known age and erupted of the left mandibular third molars. Exclusion criteria included panoramic radiographs of patients with systemic diseases, dental abnormalities, patients with presenting orthodontic appliances, or absence of left mandibular TMs either may be congenital or by extraction. Data about sex, date of birth and date of radiographs were collected for each patient.

Ethical considerations

The study was conducted according to the declaration of Helsinki and the protocol was approved by the Ethics Research Board of Beni-suef oral and maxillofacial radiology department (**World Medical Association, 2001**). Written informed consents were obtained from the adults and guardians of the minors before the enrollment in study.

Measurements

The discrimination of adults and minors was studied using Demirjian's stages of dental maturity (Demirjian et al. 1973), D to H stages were used as cut-offs points to estimate adulthood.

The left mandibular third molar of each individual was analyzed using **Navegatum DICOM viewer** software for the medical sector. e version 1.10.0.0 applicable on Microsoft .

Statistical analysis

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 25. Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Standard diagnostic indices including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic efficacy were calculated as described

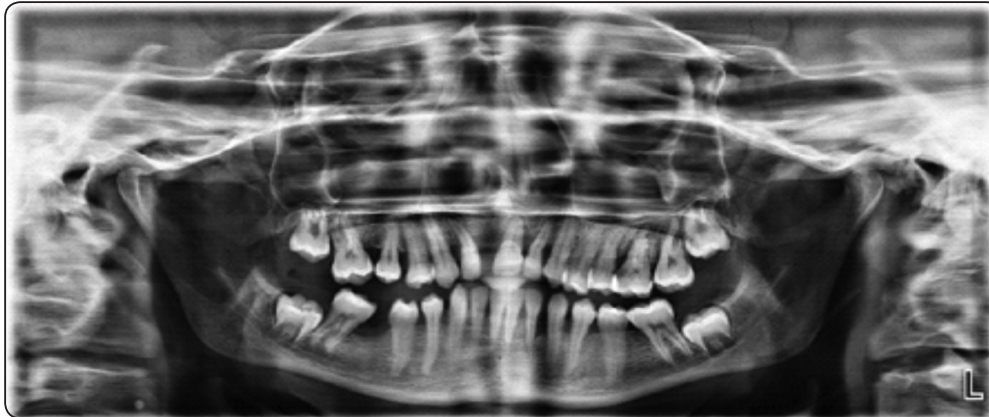


Fig. (1) Capture for E stage image for 19 years old female patient.



Fig. (2) Capture for H stage image for 20 years old male old patient.

by (Galen, 1980). ROC curve was constructed with area under curve analysis performed to detect overall effectiveness of Demirjian's stages in detection of adults. The value of the area under the ROC curve shows the accuracy of the test or how well the test identify adults from minors. An area of 1 represents a perfect test, while an area of 0.5 represents a worthless test (Fletcher and Fletcher, 2005). Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test (Chan, 2003). P value less than 0.05 was considered as statistically significant.

Equations

Positive likelihood ratio (PLR) = $\frac{\text{sensitivity}}{(1 - \text{specificity})}$

Negative likelihood ratio (NLR) = $\frac{(1 - \text{sensitivity})}{\text{specificity}}$

Positive post-test probability = PPV

RESULTS

Table 1 shows the distribution of age and sex among the studied sample of OPTs. Figure 3 illustrates the age distribution across Demirjian stages. No differences in age between sexes across all Demirjian stages (Table 2). Table 3 shows the distribution of subjects who are 18 years or older by Demirjian stages and sex. Table 4 shows the performance of the cut-off values of Demirjian stages for males and females separately by 2-by-2 contingency tables. The values of the area under the ROC curve for discriminating between adults and minors were 0.779 (95%CI, 0.669 to 0.890) for stage H, followed by 0.778 (95%CI, 0.647 to 0.908) for stage G and 0.718 (95%CI, 0.578 to 0.858) for stage F (Figure 4). Table (5) shows that among the tested Demirjian's stages, stage H showed the best specificity; 90.91% and 63.64% in males and females, respectively. The sensitivity of the test in males was 98%, 98%, and 84% for stage F, G and H respectively, and in females was 98.39%, 95.16%, and 74.19% for stage F, G, and H respectively.

TABLE (1) Distribution of age and sex among the studied Egyptian sample of panoramic radiographs

		Sex		
		Females	Males	Total
		Count	Count	Count
Age (years)	15	0	3	3
	16	5	7	12
	17	6	1	7
	18	4	2	6
	19	6	12	18
	20	9	8	17
	21	1	6	7
	22	16	9	25
	23	15	2	17
	24	6	1	7
	25	5	6	11
	26	0	4	4
	Total	73	61	134

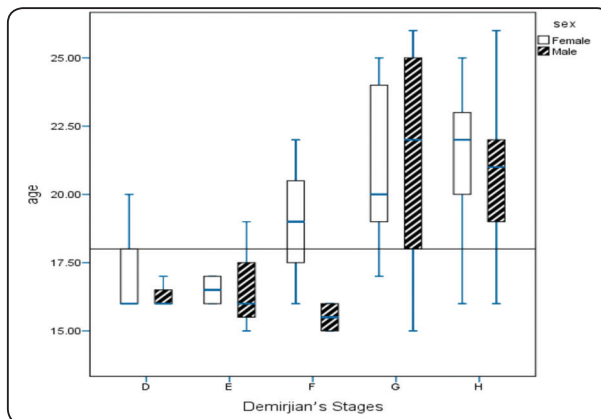


Fig. (3) Box-plot of the relationship between age and Demirjian's stages of the left mandibular third molar. The box-plots show median and inter-quartile ranges, lines extending from the box show maximum and minimum ages

TABLE (2) Summary statistics of the age (years) in relation to Demirjian's stages (D-H) of lower left third molar among Egyptian males and females

		Female age						Male age						P value
		N	Mean	SD	Median	1st quartile	3rd quartile	N	Mean	SD	Median	1st quartile	3rd quartile	
Demirjian's Stages	D	3	17.33	2.31	16.00	16.00	20.00	4	16.25	0.50	16.00	16.00	16.50	0.857
	E	2	16.50	0.71	16.50	16.00	17.00	3	16.67	2.08	16.00	15.00	19.00	0.800
	F	3	19.00	3.00	19.00	16.00	22.00	2	15.50	0.71	15.50	15.00	16.00	0.200
	G	15	21.27	2.99	20.00	18.00	24.00	9	21.11	4.20	22.00	18.00	25.00	0.953
	H	50	21.48	2.22	22.00	20.00	23.00	43	21.16	2.37	21.00	19.00	22.00	0.161

TABLE (3) The distribution of the subjects of 18 years and older within Demirjian stage in Egyptian males and females

		Females	Males
		Age >= 18	age >= 18
		N	N
Demirjian's Stages	D	1	0
	E	0	1
	F	2	0
	G	13	7
	H	46	42

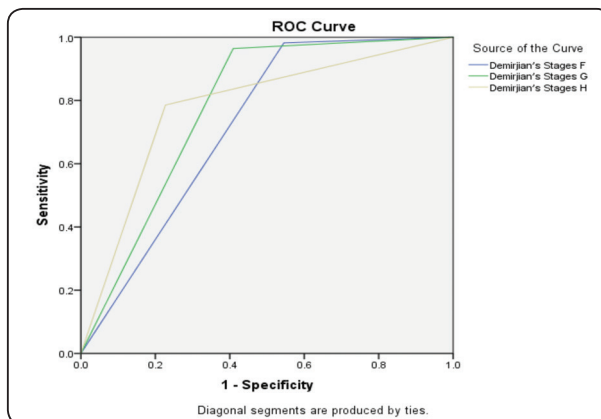


Fig. (4) Receiver operating characteristic (ROC) curve for Demirjian stages F to H of the lower left third molar for discriminating adults and minors in Egyptians.

TABLE (4) 2-by-2 Contingency table discriminating the performance of the test on being adult or minor for Demirjian's stages F to H in Egyptian males and females

		Sex					
		Female			Male		
		age groups			age groups		
		>=18	<18	Total	>=18	<18	Total
		Count	Count	Count	Count	Count	Count
Demirjian's Stages F	>=F	61	7	68	49	5	54
	<F	1	4	5	1	6	7
Demirjian's Stages G	>=G	59	6	65	49	3	52
	<G	3	5	8	1	8	9
Demirjian's Stages H	>=H	46	4	50	42	1	43
	<H	16	7	23	8	10	18
	Total	62	11	73	50	11	61

TABLE (5) Percentage of sensitivity, specificity, accuracy, and post-test probability (95% confidence interval) for Demirjian's stages F to H of the lower left third molar to test the age of majority in Egyptian males and females,

		Stage F	Stage G	Stage H
Males	Sensitivity	98.00% (89.35% to 99.95%)	98.00% (89.35% to 99.95%)	84.00% (70.89% to 92.83%)
	Specificity	54.55 % (23.38% to 83.25%)	72.73 % (39.03% to 93.98%)	90.91 % (58.72% to 99.77%)
	Positive Likelihood Ratio	2.16 (1.13 to 4.12)	3.59 (1.37 to 9.44)	9.24 (1.42 to 60.11)
	Negative Likelihood Ratio	0.04 (0.00 to 0.27)	0.03 (0.00 to 0.20)	0.18 (0.09 to 0.34)
	Positive Predictive Value	90.74% (83.67% to 94.94%)	94.23% (86.14% to 97.72%)	97.67% (86.59% to 99.64%)
	Negative Predictive Value	85.71 % (44.47% to 97.82%)	88.89 % (52.64% to 98.29%)	55.56 % (39.20% to 70.79%)
	Accuracy	90.16% (79.81% to 96.30%)	93.44% (84.05% to 98.18%)	85.25% (73.83% to 93.02%)
Females	Sensitivity	98.39% (91.34% to 99.96%)	95.16% (86.50% to 98.99%)	74.19% (61.50% to 84.47%)
	Specificity	36.36 % (10.93% to 69.21%)	45.45 % (16.75% to 76.62%)	63.64 % (30.79% to 89.07%)
	Positive Likelihood Ratio	1.55 (0.99 to 2.42)	1.74 (1.01 to 3.00)	2.04 (0.92 to 4.52)
	Negative Likelihood Ratio	0.04 (0.01 to 0.36)	0.11 (0.03 to 0.38)	0.41 (0.22 to 0.75)
	Positive Predictive Value	89.71% (84.78% to 93.17%)	90.77% (85.11% to 94.42%)	92.00% (83.85% to 96.22%)
	Negative Predictive Value	80.00 % (32.98% to 97.02%)	62.50 % (31.67% to 85.70%)	30.43 % (19.14% to 44.72%)
	Accuracy	89.04% (79.54% to 95.15%)	87.67% (77.88% to 94.20%)	72.60% (60.91% to 82.39%)

DISCUSSION

Teeth development is a progressive, continuous process that can be followed radiologically. So it is considered a reliable method for age estimation of children and adults in forensic and archaeological contexts (**Verma et al. 2011**).

The third molar has the advantage of continuous development over a long period and until a later age which makes it one of the predictors for age estimation in the 16-23 years old group (**Gandhi et al. 2014**).

This study aimed to evaluate the use of Demirjian stages of teeth development in the determination of the age of majority from the left mandibular third molar among a sample of the Egyptian population.

In this study, within the stages of root development D-H, males were ahead than females in stages D, F, G and H, and in all stages we found no statistical difference in the age between sexes.

This result is consistent with is **Quintanilla 2010**, who stated that many variables were involved in the maturation of individuals, emphasizing the sex-linked genetic trait, as is the advancement in female maturation in relation to males. Though, regarding the lower third molars, there is an advanced development in males, meaning that during adolescence there is an inverse situation between sexes. Also the same finding was observed by **Knell et al. 2009** in Swiss and South Europeans, **Harris 2007** in American black and whites, and by **Orhan et al. 2007** in Turks.

In this study we found a single adult individual in the stage D and stage E, and 2 individuals in the stage F, while 77.8% of the males and 86.6% of the females within stage G and 97.7 % males and 92% females within stage H were adults.

Similarly, **Lizarbe et al. 2017** during studying this method among Peruvian population found 2 adult persons in stage E, and 9 persons in the stage F, while 67% of the males and 87% of the females

within stage G and 97% males and 95% females within stage H were adults.

On contrary, **Treviño 2009**, found that for Mexicans from Monterrey, minors corresponded from A to F stages, and he did not found any adult individual in these classification; also adults were those who reached stage H, and 52% of persons who reached stage G were adults.

In this study, our results showed that, if the root apices of the third molar are closed (terminal stage H), there is a high probability that the subject is indeed at least 18 years of age (specificity 90.91% and 63.64% for males and females respectively).

However, individuals of adult age whose third molars are at terminal stage H (sensitivity 84% for males and 74.19% for females), and the proportion of correctly classified individuals was 85.25% for males and 72.60% for females.

Cameriere et al. 2008 showed a total sensitivity of 58%, specificity of 98%, and accuracy of 79% for stage H.

Choosing stage G as an indicator for adult age (sensitivity 98% for males 95.16% for females), will increase the sensitivity of the method but decrease the specificity significantly and increases the number of false positive cases. In forensic and medicolegal practice, an adequate test should reduce the number of false positives as much as possible (**Martin-de las Heras et al. 2008**).

In conclusion, Demirjian's stages G and H are fairly accurate and reliable for estimating the age of majority among Egyptians. However, the life of individuals may be significantly affected by the impact of criminal proceedings. It is fundamental to test different parameters and methods to determine whether a person is 18 years and older or younger than 18 (**Focardi et al. 2014**). Further studies should be performed to test this method on a larger sample, and to test the reliability of other methods in order to establish the most accurate reliable method for estimating the age of majority .

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