

# Developmental Stages of Third Molars in 16- to 22-year-old Patients Referred to a Clinic in Rafsanjan, Iran using Demirjian and Modified Gleiser and Hunt Methods

## Original Article

Zahra Tafakhori<sup>1</sup>, Ali Kamali<sup>2</sup>, Somayeh Nemati<sup>3</sup>

<sup>1</sup>Assistant Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry and Dental Research Centre, Rafsanjan University of Medical Sciences, Rafsanjan, Iran

<sup>2</sup>Dentist, School of Dentistry and Dental Research Centre, Rafsanjan University of medical sciences, Rafsanjan, Iran.

<sup>3</sup>Assistant Professor of Maxillofacial Radiology, Department of Maxillofacial Radiology, Faculty of Dentistry, Guilan University of Medical Sciences, Rasht, Iran

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### Corresponding Author:

**Dr Zahra Tafakhori**

#### Address:

Department of Oral and Maxillofacial Radiology, School of Dentistry and Dental Research Centre, Rafsanjan University of Medical Sciences, Aliebneabital-eb Square, Rafsanjan, P.O.Box:7717931136, Iran

**Telephone: +98-391-8220031**

**Fax: +98-391-8220008**

**Email: ztafakhori@yahoo.com**

## Abstract

### Introduction:

Age estimation is an important issue in forensics, particularly for treatment planning and determining patients' rights. Radiographic evaluation of the third molar developmental stage is a significant criterion for age estimation. The pattern of tooth development is largely heritable and varies from race to race. The objective of this study was to radiographically examine and compare the developmental stages of the third molars with the chronological age of Rafsanjan's young individuals.

### Materials and methods:

This cross-sectional study was performed on 215 patients aging 16–22 years that presented to a private oral and maxillofacial radiology clinic in Rafsanjan, Iran for panoramic radiography. Using the panoramic radiographs, the developmental stages of the third molars were determined and recorded using two methods: the Demirjian and Modified Gleiser and Hunt methods. The data thus obtained were statistically analyzed; mean age of each developmental stage for each sex was determined and regression equations for age estimation were calculated.

### Results:

In both developmental classification methods, males preceded females in terms of dental development ( $P < 0.001$ ). Furthermore, there were strong correlations between teeth 18 and 28 and between teeth 38 and 48 in both males and females by either method ( $P < 0.001$ ). Chronological age was acceptably predicted on the basis of the gender and developmental stages of the teeth 28 and 48 using both methods ( $R^2 = 45.4\%$ , Demirjian method;  $R^2 = 42.5\%$ , Modified Gleiser and Hunt method).

### Conclusion:

The results suggest that third molar developmental stages studied using panoramic radiographs could be suitable for estimating chronological age.

**Key words:** •Molar •Third. Radiography •Panoramic •Age Determination by Teeth

## Introduction

Age estimation is an important issue in forensics, particularly for treatment planning and determining patients' rights. Considering increased requests from forensics for age estimation in cases such as unidentified corpses, criminals concealing their age, and people claiming that their age is not the same as that mentioned in their identification card, scholars are always researching for new methods of age estimation.<sup>(1)</sup>

In most countries, estimation of age in adolescents and young individuals is required. Moreover, the age range of 14–20 years is the threshold for social and legal issues. Therefore, a reference for age estimation is needed during this period. However, little information is available about age estimation for this age group.<sup>(2, 3)</sup>

Bone age is the most accurate and common method of age estimation, and bones of the hand and wrist are commonly used in this method.<sup>(4)</sup> However, dentists have turned to determining dental age because the use of bone age is difficult and time-consuming, and patients need to pay more and receive higher doses of radiation.<sup>(5)</sup>

Different methods have been used for evaluating dental development using radiography.<sup>(6–8)</sup> Of these, the Demirjian method of dental age assessment has been used more frequently than other methods<sup>(10)</sup> because it is more accurate<sup>(6, 10–11)</sup> and has more clearly defined developmental stages.<sup>(12, 13)</sup>

However, the limitation of the Demirjian method is that it can estimate age only up to the end of calcification of seven teeth (formation of dental apex), i.e., up to the age of 16 years, because it estimates age according to the developmental stage of the seventh permanent tooth on the panoramic radiograph.<sup>(14)</sup>

Another method widely used to estimate age is the Modified Gleiser and Hunt method.<sup>(15)</sup>

Although the developmental process of teeth is a valuable index for estimating children's age, its accuracy decreases in adolescents and adults whose tooth development is nearly complete.<sup>(3, 16, 17)</sup> According to forensics, the critical age that establishes legal accountability and rights is above 15 years,<sup>(14)</sup> and the third molars are the only teeth whose developmental stages are not complete in adults. The developmental process usually continues up to the age 22 years,<sup>(18)</sup> such that the age

range of these people can be estimated through evaluation of their third molar development.

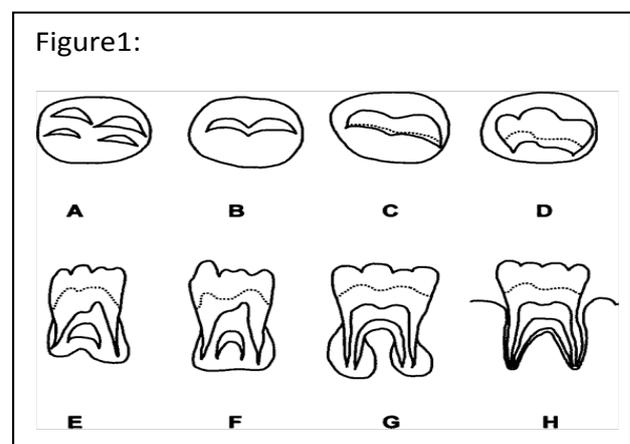
Previous studies<sup>(17, 19, 20)</sup> showed that the third molar development varies with population, and consequently, a reference specific to a given population is necessary for estimating the age in that population.<sup>(17, 21, 22)</sup>

Given that few studies have been performed for estimating dental age using third molar teeth in an Iranian population, this study was conducted to evaluate the third molar developmental stages in patients of the above discussed age range using the Demirjian and Modified Gleiser and Hunt methods in order to obtain regression equations between chronological age and third molar developmental stages.

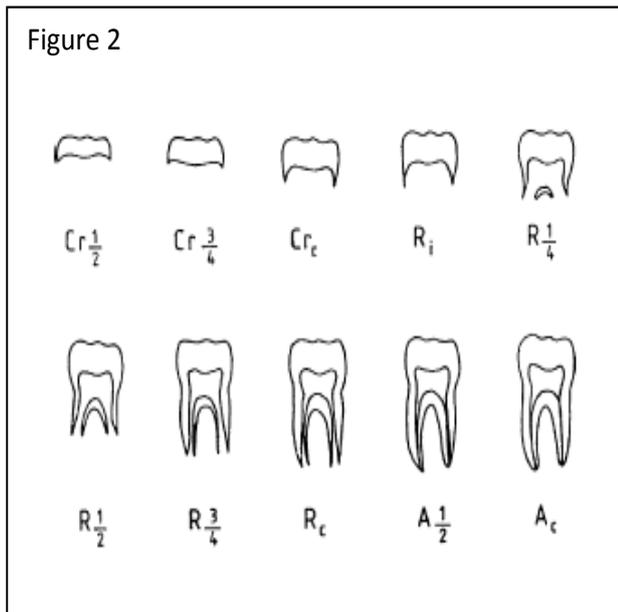
## Materials and Methods

This cross-sectional study was performed on 215 patients aged 16–22 years presenting to a private oral and maxillofacial radiology clinic in Rafsanjan to obtain panoramic radiographs for dental procedures.

The patients' radiography was performed using a digital panoramic device (Planmeca Proline-XC; Planmeca, Helsinki, Finland) and printed using a printer (Konica, Tokyo, Japan). All the radiographs were obtained under standard conditions without any technical errors. The radiographs were included in the study only if the patients were from Rafsanjan, had at least one third molar bud, and did not have any of the following: systemic or metabolic diseases, any factors affecting third molar development, or a history of trauma or surgery.



**Figure 1:** Schematic representation of the eight stages of third molar development as per the Demirjian method



**Figure 2:** Schematic representation of the stages of third molar development as per the Modified Gleiser and Hunt method

There after, the third molar developmental stages were determined by the Demirjian (Figure 1) and the Modified Gleiser and Hunt (Figure 2) methods by an observer using the panoramic radiographs in a half-dark room with a negatoscope under uniform light.

The observations were recorded in a checklist prepared for each patient. Once the third molar developmental stages were determined for both female and male groups, the developmental stages of the teeth and the chronological age were compared.

The patients' chronological age was determined on the basis of the information in their identification card (the difference between the birth date recorded on the identification card and the date of panoramic radiography).

The data thus obtained were analyzed using SPSS 18.0 software (SPSS Inc., Chicago, IL, USA). Multiple linear regression analysis through stepwise selection of variables was used to predict the chronological age of patients on the basis of their third molar developmental stages using the Demirjian and the Modified Gleiser and Hunt methods.

Moreover, the Spearman's nonparametric correlation coefficient was used to examine the correlation between the developmental stages of different third molars using the two methods. The chi-square test was used to compare the frequency distribution of the tooth developmental

stages in females and males by each method. The significance level was set at 0.05.

## Results

In this cross-sectional study, 215 panoramic radiographs were studied, of which 120 (55.8%) and 95 (44.2%) radiographs were related to girls and boys, respectively. Maximum and minimum age of the patients was respectively 22 years and 16.01 years, and mean age of the patients was  $19.24 \pm 1.82$  years.

Based on the results, most of the third molar teeth were at stages F, G, and H in boys and stages F and G in girls through Demirjian method (table 1). In Modified Gleiser and Hunt method, most of the third molar teeth were at stages R3/4 and A1/2 (table 2).

All the patients whose third molar teeth were developed (stage H in Demirjian method or stage Ac in Modified Gleiser and Hunt method) were over 18.22 years old.

Using the multiple linear regression analysis through stepwise selection variable (based on which the developmental stages of teeth 28 and 48 had a significant correlation with the estimated age, whilst the developmental stages of teeth 18 and 38 were excluded from the regression model fitted to the data due to the lack of a significant correlation between them and the estimated age), the equation for predicting patients' age based on sex and developmental stages of teeth 28 and 48 variables for each developmental method was obtained as follows:

The equation for predicting patients' age based on sex and developmental stages of teeth 28 and 48 in Demirjian method:

$$\text{Estimated age} = 8.322 + (0.790 \times \text{developmental stage of tooth 28}) + (0.706 \times \text{developmental stage of tooth 48}) + (0.593 \times \text{sex})$$

$$R^2 = 45.4\%$$

The equation for predicting patients' age based on sex and developmental stages of the third molar (teeth 28 and 48) in Modified Gleiser and Hunt method:

$$\text{Estimated age} = 12.548 + (0.413 \times \text{developmental stage of tooth 28}) + (0.375 \times \text{developmental stage of tooth 48}) + (0.502 \times \text{sex})$$

$$R^2 = 42.5\%$$

Table 1: Mean age of developmental stages in each of the third molars in Demirjian method in both genders separately

Gender	Male				Female				
	Stage	n.	Min.	Max.	Mean±SD	n.	Min.	Max.	Mean±SD
<b>Dem. 18</b>									
	<b>D</b>	3	16.02	17.69	16.59±0.96	5	16.16	21.06	17.54±2.12
	<b>E</b>	8	16.03	20.37	17.60±1.70	14	16.01	19.46	17.40±1.26
	<b>F</b>	16	16.02	20.87	18.25±1.71	37	16.09	21.43	18.68±1.63
	<b>G</b>	41	17.30	21.89	19.64±1.52	48	16.05	22.00	20.10±1.54
	<b>H</b>	15	19.35	21.72	20.81±0.63	9	19.92	21.95	21.20±0.60
<b>Dem. 28</b>									
	<b>D</b>	3	16.02	17.69	16.59±0.96	4	16.16	17.76	16.60±0.78
	<b>E</b>	7	16.03	18.11	17.03±0.86	11	16.01	19.06	17.17±1.00
	<b>F</b>	17	16.03	20.87	18.36±1.82	41	16.05	21.43	18.67±1.71
	<b>G</b>	37	17.30	21.89	19.51±1.51	47	16.50	22.00	20.14±1.51
	<b>H</b>	21	18.22	21.87	21.54±0.99	10	19.92	21.95	20.95±0.75
<b>Dem. 38</b>									
	<b>D</b>	1	16.03	16.03	16.03	3	16.16	21.06	18.90±2.50
	<b>E</b>	5	16.05	17.69	16.71±0.73	7	16.01	17.85	16.72±0.70
	<b>F</b>	19	16.02	20.85	18.20±1.63	38	16.05	21.48	18.28±1.80
	<b>G</b>	42	16.02	21.89	19.31±.61	50	16.19	22.00	20.06±1.54
	<b>H</b>	22	18.22	21.72	20.53±0.96	10	18.81	21.98	20.68±1.13
<b>Dem. 48</b>									
	<b>D</b>	2	16.03	16.05	16.04±0.01	3	16.16	21.06	18.90±2.50
	<b>E</b>	4	16.08	17.69	16.88±0.72	9	16.01	19.80	17.20±1.22
	<b>F</b>	22	16.02	20.90	18.19±1.57	35	16.05	21.48	18.10±1.73
	<b>G</b>	42	16.02	21.89	19.19±1.54	55	16.19	22.00	20.13±1.49
	<b>H</b>	21	18.22	21.87	20.58±0.98	9	18.81	21.98	20.93±1.14

The equation for predicting patients' age based on sex and developmental stages of the third molar (teeth 28 and 48) in Modified Gleiser and Hunt method:

$$\text{Estimated age} = 12.548 + (0.413 \times \text{developmental stage of tooth 28}) + (0.375 \times \text{developmental stage of tooth 48}) + (0.502 \times \text{sex})$$

R2 = 42.5%

The following values were substituted for the developmental stages of tooth variables in the related equation:

The developmental stages of teeth in Demirjian method: D = 4, E = 5, F = 6, G = 7, and H = 8

The developmental stages of teeth in Modified Gleiser and Hunt method: Crc = 3, Ri = 4, R1/4 = 5, R1/2 = 6, R3/4 = 7, Rc = 8, A1/2 = 9, and Ac = 10.

Furthermore, values 1 and 2 were substituted for male sex and female sex, respectively.

Using the Spearman's nonparametric correlation coefficient, the following results were obtained:

-There was a significant correlation between

teeth on both sides of each jaw (between teeth 18 and 28 and also between teeth 38 and 48) in boys and girls in both Demirjian and Modified Gleiser and Hunt methods.

-In Demirjian method, the highest correlation existed between the third molars of mandible in boys and girls; In Modified Gleiser and Hunt method, the highest correlation existed between the third molars of the maxilla in boys and between the third molars of mandible in girls.

-There was also a significant correlation between Demirjian and Modified Gleiser and Hunt methods. In this study, the two methods did not show any significant difference (P>0.05) between dental development of the third molars on the right and left sides and also between dental development of the lower and upper third molars in boys and girls. According to tables 3 and 4 in both methods, there was a significant difference between boys and girls in terms of the development of the third molars, as the boys preceded girls in this regard (P<0.001).

**Table 2:** Mean age of developmental stages in each of the third molars in Modified Gleiser and Hunt method in both genders separately

Gender	Stage	Male			Female				
		n.	Min.	Max.	Mean±SD	n.	Min.	Max.	Mean±SD
<b>Mod. 18</b>									
	Ri	7	16.09	20.37	17.74±1.84	7	16.16	21.06	18.08±1.97
	R1/4	7	16.02	18.72	17.04±1.04	24	16.01	21.43	18.11±1.77
	R1/2	8	16.44	20.85	18.70±1.72	15	16.22	21.17	18.20±1.53
	R3/4	18	16.18	21.83	18.6±1.74	23	16.05	21.98	19.04±1.67
	Rc	11	17.87	21.87	19.97±1.53	14	16.74	22.00	20.47±1.53
	A1/2	23	17.59	21.89	20.17±1.35	23	17.64	21.95	20.48±1.17
	Ac	9	19.35	21.64	20.61±0.71	7	19.92	21.95	21.16±0.69
<b>Mod. 28</b>									
	Ri	5	16.02	18.04	16.77±1.00	4	16.16	17.75	16.60±0.78
	R1/4	8	16.02	20.37	17.68±1.68	21	16.01	21.43	17.87±1.77
	R1/2	6	16.44	20.85	18.37±1.82	19	16.09	21.17	18.38±1.60
	R3/4	18	16.18	21.83	18.72±1.83	24	16.05	21.98	19.31±1.57
	Rc	12	17.65	21.20	19.31±1.34	17	16.74	22.00	20.20±1.64
	A1/2	27	17.59	21.89	20.22±1.31	20	18.15	21.95	20.52±1.14
	Ac	9	18.22	21.64	20/49±1.00	8	19.92	21.95	21.02±0.74
<b>Mod. 38</b>									
	Crc	--	--	--	--	1	21.06	21.06	21.06
	Ri	2	16.03	16.08	16.05±0.03	3	16.16	19.49	17.86±1.66
	R1/4	4	16.51	17.69	16.17±0.49	12	16.01	19.17	16.89±1.01
	R1/2	12	16.02	20.85	17.99±1.61	19	16.60	21.48	18.75±1.79
	R3/4	24	16.02	21.83	18.84±1.72	27	16.05	22.00	18.88±1.78
	Rc	9	16.18	21.19	19.24±1.75	10	16.19	21.68	19.89±1.78
	A1/2	24	17.65	21.89	20.03±1.40	28	17.05	21.95	20.29±1.35
	Ac	14	18.22	21.64	20.40±1.07	8	19.39	21.98	21.00±0.97
<b>Mod. 48</b>									
	Ri	3	16.03	16.08	16.05±0.02	4	16.16	21.06	18.66±2.10
	R1/4	6	16.51	20.37	17.70±1.36	15	16.01	19.80	17.19±1.23
	R1/2	12	16.02	20.85	18.13±1.51	16	16.60	21.48	18.86±1.84
	R3/4	24	16.02	21.61	18.64±1.58	29	16.05	22.00	18.85±1.83
	Rc	9	16.18	21.16	18.88±1.67	14	16.19	21.95	20.19±1.62
	A1/2	22	17.69	21.89	19.99±1.35	25	17.05	21.95	20.39±1.40
	Ac	15	18.22	21.87	20.58±1.00	8	18.81	21.98	20.87±1.20

**Table 3:** Comparing the frequency distribution of the third molars' developmental stages in girls and boys in Demirjian method

Stage	H	G	F	E	D
<b>Gender</b>					
Male	22.7%	46.6%	21.3%	6.9%	2.6%
Female	8.5%	44.9%	33.9%	9.2%	3.4%

**Table4:** Comparing the frequency distribution of the third molars' developmental stages in girls and boys in Modified Gleiser and Hunt method

Stage	Ac	A1/2	Rc	R3/4	R1/2	R1/4	Ri
<b>Gender</b>							
Male	13.5%	27.6%	11.8%	24.1%	10.9%	7.2%	4.9%
Female	7/0%	21.6%	12.4%	23.2%	15.5%	16.2%	4.1%

## Discussion

The legal and social problems begin in the age range of 14-20 years. However, there is little information about age estimation of this age group.<sup>(2, 3)</sup> The developmental stages of teeth provide valuable information about estimating children's age, but this information in adolescents and adults whose teeth are almost developed are of less value.<sup>(3, 16, & 17)</sup> However, the third molars are the only teeth whose developmental stages last up to the age 22 years.<sup>(18)</sup> Therefore, individual's age in this age group can be estimated by investigating developmental stages of their third molar teeth.

In the present study, in Demirjian method, 100% of boys and girls whose third molars were developed completely (stage H), aged over 18.22 years. These findings conform to Meinl et al.'s study<sup>(10)</sup> on an Austrian population where 100% of males and females who had their third molar on the right side of mandible at stage H, aged over 18 years, while 99.1% of males and 98.7% of females whose third molar on the left side of mandible was at stage H aged over 18 years. However, in Arany et al.'s study<sup>(23)</sup> on the Japanese, minimum age related to that developmental stage was 21.2 years. In Modified Gleiser and Hunt method in this study, 100% of boys and girls whose third molars were developed completely (stage Ac) aged over 18.22 years, which conforms to Gunst et al.'s study<sup>(24)</sup> on people whose third molar was developed completely aged over 18 years. Moreover, in Bagherpour et al.'s study<sup>(20)</sup>, 100% of females and 95.6% of males with third molars at this stage of development aged over 18 years. These differences might be due to the different selected age range in the above studies and also a proof for the theory of racial impact on dental development.

In Demirjian method in this study, there was a significant difference between boys and girls in terms of the development of the third molars, as the boys preceded girls in this regard ( $P < 0.001$ ).

This result agreed with that of studies conducted by Mohtavipour<sup>(2)</sup>, Sang<sup>(25)</sup>, Sisman<sup>(26)</sup>, Kasper<sup>(16)</sup>, and Arany.<sup>(23)</sup> However, Orhan et al.'s study<sup>(27)</sup> did not show any significant difference between females and males in terms of the development of the third molars. In Modified Gleiser and Hunt method in this study, a significant difference was observed between boys and girls in this regard, as the boys preceded girls in terms of the development of the third molars ( $P < 0.001$ ), and this result conformed to that of Gunst et al.'s study.<sup>(24)</sup>

In Demirjian method in this study, Spearman nonparametric correlation coefficient was used and revealed the highest correlation in boys and girls existed between the upper right third molars and the upper left third molars and between the lower right third molars and the lower left third molars. These findings agree with those of studies by Mohtavipour et al.<sup>(2)</sup>, Orhan et al.<sup>(27)</sup>, and Meinl et al.<sup>(10)</sup> In Modified Gleiser and Hunt method, the highest correlation in boys and girls existed between the upper right third molars and the upper left third molars and between the lower right third molars and the lower left third molars. These findings conform to those of studies by Bagherpour et al.<sup>(20)</sup> and Messoten et al.<sup>(28)</sup>

In this study, Demirjian method did not show any significant difference between right and left third molars on the upper and lower jaw in both boys and girls ( $P > 0.05$ ), and this result is similar to that of studies performed by Mohtavipour et al.<sup>(2)</sup>, Orhan et al.<sup>(27)</sup>, and Meinl et al.<sup>(10)</sup> However, Ajami et al.'s study<sup>(21)</sup> showed a significant difference in this regard, as the left side preceded the right side. In Modified Gleiser and Hunt method in this study, no significant difference existed between right and left third molars on the upper and lower jaw in both boys and girls ( $P > 0.05$ ), and this result agrees with that of studies by Messoten et al.<sup>(28)</sup> and Bagherpour et al.<sup>(20)</sup> In the present study, the two methods showed that the lower third molar development preceded the upper third molar development, but this dif-

ference was not significant. This result conforms to that of Ajami et al.'s study<sup>(21)</sup> but does not conform to that of the studies by Mohtavipour et al.<sup>(2)</sup>, Kasper et al.<sup>(16)</sup>, and Arany et al.<sup>(23)</sup> who reported a significant difference between molars of the lower and upper jaws, as the upper third molar development preceded the lower third molar development.

In general, the differences between the present study and the similar previous studies might be due to the impact of race and region on the development of teeth, and this might prove the specificity of the third molar development in every population<sup>(3, 17, 19, & 20)</sup>

## Conclusion

Regarding the results of this study, it seems that the use of third molar developmental stages

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in panoramic radiography can be suitable for determining chronological age. Further similar studies on different races and nationalities and meta-analyses can provide score tables for the third molar similar to Demirjian tables for teeth 1 to 7. Given almost similar results were obtained in the two methods, none is preferred to the other, but modified Gleiser and Hunt method can cause more researcher errors due to more detailed classification.

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