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Dental age estimation with special emphasis on age limits of 12/15 and 18 years: Detailed analysis according to governing law

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ABSTRACT

Objective: The aim of this study is to investigate the potential of Demirjian method in estimation of age groups with limits of 12, 15, and 18 years, according to ages of legal responsibilities.

Methods: The panoramic radiographs of the study population aged between 6 to 22 were assessed for third molar (3M) mineralization with Demirjian method with four subgroups. Group 1 consisted of individuals aged between 6 to and 12 years of age, Group 2 were aged between 12 to 15 (Group 2, ≥12, <15), Group 3 were aged between 15-18 years (Group 3, ≥15, <18) and Group 4 were aged over-18s (Group 4, ≥18). Chronological age, developmental stages of 3Ms, differences between bilateral 3M stages and their relations between age groups were evaluated.

Results: Regarding all 3M mineralization evaluations, stages 0 and A for Group 1; stages C and D for Group 2; stages E and F for Group 3; stage H for Group 4 was found to be high in percent (p<.05). Regarding the bilateral evaluations, the most variations were in readings of stages B, C, E and G as two stages below and one stage above the concordance.

Conclusion: Use of Demirjian method facilitated discrimination of specific age groups with 12, 15, and 18 age thresholds in a sample of a young Turkish subpopulation from the Northwest Anatolia. Regarding the staging assessment in Demirjian method, independent evaluation of each side must be considered for bilateral 3Ms.

Keywords: Age estimation, demirjian method, legal responsibility, governing law

1.INTRODUCTION

Amongst the dental age estimation methods, Demirjian's method is of particular interest and is widely applied in forensic studies (1). Using panoramic radiographs, this reliable and convenient system evaluates crown and root formation with a total maturity score which is converted into an estimated dental age (2). Considering the development of teeth, third molar mineralization has a unique advantage over the others, since its development begins at 5 and completes between 18 to 25 years of age (3). Due to this relatively prolonged process, the third molar (3M) is often assessed for estimation of chronological age especially for the late adolescence period (4). On the other hand, studies report geographic variations may result in overestimation of dental age in relation to the chronological age (5). Therefore, it was suggested to develop different estimation calculations based on local population characteristics (6).

With a special emphasis on the estimation of juvenile and adult status, most age estimation studies focus on the 18-year-old threshold. This discrimination is also important for the juvenile sub-groups as the definition child changes to adult. In Turkey, children under the age of 12 are exempt from criminal liability whereas children among 12 to 15 years and 15 to 18 years have different procedures according to the Turkish Penal Code (7). These age groups are defined due to the individual's capability to comprehend the legal meaning, to appreciate the result of the act and to control behaviors in respective of act. In addition to criminal liability, those age limits are also important in various legal regulations such as the identification age of the victim, or social events like marriage (8). Therefore, particularly for juveniles devoid of identification documents, age estimation is required for proceedings of legal procedures. Most of the age limits are set in European countries between 10 and 16 years. For example, in Switzerland, England and Wales children can be held liable for criminal offences from the age of 10. The minimum age in Austria, Spain, Hungary, Bulgaria, and Germany is 14 years of age. Like Turkey, Belgium, Netherlands and Ireland have a minimum age of 12 (9). Considering the majority of dental age estimation studies are interested in discrimination of adult and juvenile, there is a need of a detailed analysis of those above-mentioned age limit groups from a forensic, medicolegal point of view.

To the best of our knowledge, there are only a few dental age estimation studies evaluating those legally relevant specific

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age groups. Therefore, the aim of this study is to investigate the potential of Demirjian method in discrimination of groups with age limits of 12, 15, and 18 years in a sample of a young Turkish subpopulation from the Northwest Anatolia.

2. METHODS

2.1. Case Selection

The study protocol was carried out according to the principles described in the Declaration of Helsinki, including all amendments and revisions. The Ethics Committee of Bolu Abant Izzet Baysal University approved this retrospective study (approvel date 04.01.2022 and number 2021/312). The panoramic radiographs (OPGs) of patients were referred to the of Bolu Abant Izzet Baysal University, Faculty of Dentistry between 2015 and 2021 were retrospectively evaluated for bilateral mandibular 3M mineralization. OPGs were acquired using Sorodex Cranex Novus (Tuusula, Finland) which was operated at 60-70 kVp and 8-10 mA. Patients with any systemic disease that would affect mineralization process, patients with evidence of any pathological entities and dental anomalies associated with the 3M and patients with trauma and surgical operation history associated were excluded from the study. OPG images with poor quality were also excluded.

2.2. Study Group Formation

Regarding the mineralization process of the mandibular 3M, the minimum and maximum age limit of the study group was set as 6 to 22 years (10). Regarding the specific age limits, four subgroups were formed. Group 1 (n=139) consisted of individuals aged between 6 to and 12 years of age (Group 1, <12) whereas individuals of Group 2 (n=120) were aged between 12 to 15 (Group 2, ≥12, <15), individuals of Group 3 (n=126) were aged between 15-18 years (Group 3, ≥15, <18) and individuals of Group 4 (n=124) were aged over-18s (Group 4, ≥18). Chronological ages were calculated by subtracting the date of birth of each individual from the date of panoramic radiograph. Demographic data of each case were recorded.

2.3. Scoring and Data Analysis

All the OPGs were anonymized as numbers, adjusted, and exported as noncompressed tagged image file format (*tiff) for observer evaluation. The images did not contain any demographic data. A blind observer rated all images in a random order during evaluation (F.A.K.) All the left mandibular 3Ms and all the right mandibular 3Ms were evaluated in separate sessions. 102 images were reevaluated after a one-month interval in order to assess the intraobserver reliability.

All mandibular molars were rated with Demirjian's method (Figure 1) with an additional stage referring to the radiolucent bud formation of the 3M pointing the beginning of calcification.

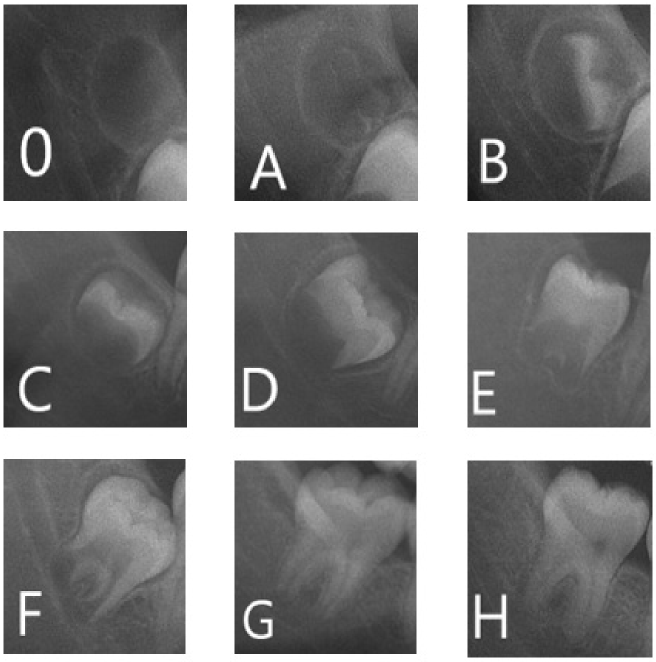

Figure 1. *Mineralization stages of mandibular third molar in cropped panoramic radiograph images. A) Stage 0: Radiolucent bud exists without any calcification. B) Stage A: Mineralization starts in cusp tips with single calcified points. C) Stage B: Fused mineralized points are recognizable. D) Stage C: Dentin accumulation starts after completion of enamel formation. E) Stage D: Crown formation is completed to the level of cementoenamel junction. F) Stage E: Formation of the root bifurcation starts. The root length remains shorter than the crown height. G) Stage F: The root length is equal to or greater than the crown height. Apical end is open with funnel shaped endings. H) Stage G: The root length is greater than the crown height. The dentin in the walls of root canal is parallel. I) Stage H: The apical ends of the roots are completely closed.*

2.4. Statistical analysis

Descriptive statistics for each variable data were calculated. Chronological age, developmental stages of teeth 38 and 48 and relations between age groups were evaluated by Pearson chi-square analysis. Data analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS, version 23 for Windows, Armonk, NY: IBM Corp). Statistical significance was set at $p < .05$. The intra-observer reliability was assessed by kappa values.

3.RESULTS

The study group consisted of 208 males (40.9%) and 301 females (59.1%) with a mean age of 14.34 ± 4.25. A total of 509 OPG images were examined with 509 lower right and 509 lower left mandibular 3Ms. The intra-observer reliability was found to be almost perfect with a kappa value of .966 (p<.001).

The developmental stages of the study group and descriptive statistics of chronological ages according to sex were given in Table 1.

Table 1. *The developmental stages of the study group and descriptive statistics of chronological ages according to sex*

		Left Mandibular Third Molar								Right Mandibular Third Molar							
		N	Mean	SD	Min	Max	Percentiles			N	Mean	SD	Min	Max	Percentiles		
Stage	Sex						25th	Median	75th						25th	Median	75th
0	M	18	8.00	1.495	6	12	7.0	8.0	8.2	13	7.54	.776	6	9	7.0	8.0	8.0
	F	14	7.50	.760	7	9	7.0	7.0	8.0	13	7.46	.660	7	9	7.0	7.0	8.0
A	M	18	9.11	1.410	7	12	8.0	9.0	10.0	20	8.65	1.226	7	12	8.0	8.5	9.0
	F	29	8.86	1.505	6	12	8.0	9.0	10.0	26	8.62	1.416	6	12	7.6	8.5	10.0
B	M	39	10.46	1.570	8	14	9.0	10.0	12.0	39	10.49	1.537	8	14	9.0	10.0	12.0
	F	35	10.29	1.673	8	14	9.0	10.0	11.0	38	10.34	1.849	8	16	9.0	10.0	11.3
C	M	23	12.35	1.071	10	14	12.0	12.0	13.0	24	12.08	.881	10	14	12.0	12.0	13.0
	F	33	13.24	1.601	10	16	12.0	13.0	14.5	34	13.06	1.613	10	17	12.0	13.0	14.0
D	M	9	13.56	2.128	11	17	12.0	13.0	15.5	9	13.56	1.509	12	17	12.5	13.0	14.0
	F	30	14.23	1.633	11	18	13.0	14.0	15.0	28	14.11	1.449	11	18	13.0	14.0	15.0
E	M	24	15.21	1.793	12	19	14.0	15.0	17.0	24	15.21	1.641	13	18	14.0	15.0	17.0
	F	58	15.34	1.743	12	19	14.0	15.0	17.0	53	15.21	1.758	12	20	14.0	15.0	16.0
F	M	19	16.58	1.071	14	18	16.0	16.0	18.0	21	16.43	1.502	12	19	16.0	16.0	17.5
	F	28	16.50	2.269	14	22	15.0	16.0	17.8	37	16.46	1.773	14	21	15.0	16.0	18.0
G	M	24	18.29	1.601	15	22	17.0	18.5	19.0	24	18.38	1.689	15	22	17.0	18.5	19.0
	F	45	18.31	2.109	15	22	17.0	18.0	20.0	45	18.51	2.191	15	22	17.0	19.0	20.0
H	M	34	20.44	1.211	17	22	19.8	21.0	21.0	34	20.38	1.231	17	22	19.0	20.5	21.0
	F	29	20.66	1.344	18	22	20.0	21.0	22.0	27	20.74	1.289	18	22	20.0	21.0	22.0

M: Male; F: Female; N: Number of individuals; SD: Standard Deviation; Min: Minimum; Max: Maximum, 25th: 75th

Distribution of number of individuals for each age group according to sex and developmental stage is presented in Table 2 for left mandibular 3M and in Table 3 for right mandibular 3M. For both tables, it was observed that in terms of number and percentage, distribution of age groups in developmental stages varied significantly for each sex and for all individuals regardless of sex (p<.001).

Stage distributions in age groups according to Table 2 were as follows; Group 1: stages 0, A and B were high in percent; stages E, F, G and H were not present. Group 2: stages C and D were high in percent; stages G and H were not present. Group 3: stages E and F were high in percent; stages 0, A, B and C were not present. Group 4: stage H was high in percent; stages 0, A, B, C and D were not present. Above presented distributions were same for all groups for both males and females, except Group 2 and 4 for females. The differences from the above distributions were stage 0 was also not present in Group 2 and stage D existed in Group 4. The absent stages for all age groups of left mandibular 3Ms were as follows; Group 1: stages E, F, G, H were not present. Group 2: stages G, H were not present. Group 3: stages 0, A, B were not present. Group 4: stages 0, A, B and C were not present.

According to Table 3, stages 0 and A for Group 1, stages C and D for Group 2, stage E for Group 3 and stages F and H Group 4 were found to be statistically high in percent for both males and females. The absent stages according to sex were as; Group 1: stages D, E, F, G and H were not present in males whereas stages E, F, G, H were not present in females. Group 2: stages 0, G, H were not present in both males and females. Group 3: stages 0, A, B and C were not present in males whereas stages 0, A, H were not present in females. Group 4: stages 0, A, B, C and D were not present in males whereas stages 0, A, B, C were not present in females. The absent stages for all age groups of right mandibular 3Ms were as follows; Group 1: stages E, F, G, H were not present. Group 2: stages 0, G, H were not present. Group 3: stages 0, A, H were not present. Group 4: stages 0, A, B and C were not present.

Table 4 presents distribution of number of individuals for each age group according to sex and developmental stage for both right and left mandibular 3Ms. The statistically high stages according to sex were as; Group 1: stages 0 and A were high for both in males and females. Group 2: stages C and D were high for both in males and females. Group 3: stages E and F were high for both in males and females. Group 1: stage H was high for males whereas stages G and H were high for females. The absent stages according to sex were as; Group 1: stages E, F, G and H were not present in both males and females. Group 2: stages G, H were not present in males whereas stages 0, G and H were not present in females. Group 3: stages 0, A, B, C and H were not present in males whereas stages 0, A, H were not present in females. Group 4: stages 0, A, B, C and D were not present in males whereas stages 0, A, B, C were not present in females. For all individuals of the study group for both mandibular 3Ms; stages 0 and A for Group 1; stages C, D in Group 2; stages E, F in Group 3; stage H in Group 4 were found to be significantly higher in percent. stages E, F, G, H were not present for Group 1 and stages G, H for Group 2, stages 0, A for Group 3 and stages 0, A, B and C were not present in Group 4 (Figure 2).

Table 5 shows the bilateral mandibular 3M presentation of developmental stages compliance. Number of matching stages were in the majority for every stage group. But there were also some unmatching for every developmental stage in both males and females, except for stage 0 of males. In this group, there was a full compliance of developmental stages.

Table 2. *Left mandibular third molar specific distribution of number of individuals for each age group according to sex and developmental stage*

	Stage	Group 1		Group 2		Group 3		Group 4		*Total*
		N	%	N	%	N	%	N	%	N
Male	0	17	94.4^{a}	1	5.6^{c}					18
	A	16	88.9^{a}	2	11.1^{c}					18
	B	28	71.8^{a}	11	28.2^{b}					39
	C	4	17.4^{b}	19	82.6^{a}					23
	D	1	11.1^{b}	6	66.7^{a}	2	22.2^{b}			9
	E			10	41.7^{b}	12	50.0^{a}	2	8.3^{d}	24
	F			1	5.3^{c}	13	68.4^{a}	5	26.3^{c}	19
	G					9	37.5^{b}	15	62.5^{b}	24
	H					1	2.9^{c}	33	97.1^{a}	34
Female	0	14	100.0^{a}							14
	A	27	93.1^{a}	2	6.9^{c}					29
	B	27	77.1^{a}	8	22.9^{b}					35
	C	3	9.1^{b}	22	66.7^{a}	8	24.2^{b}			33
	D	2	6.7^{b}	16	53.3^{a}	11	36.7^{b}	1	3.3^{d}	30
	E			18	31.0^{b}	36	62.1^{a}	4	6.9^{d}	58
	F			4	14.3^{bc}	17	60.7^{a}	7	25.0^{c}	28
	G					17	37.8^{b}	28	62.2^{b}	45
	H							29	100.0^{a}	29
Total	0	31	96.9^{a}	1	3.1^{c}					32
	A	43	91.5^{a}	4	8.5^{c}					47
	B	55	74.3^{b}	19	25.7^{b}					74
	C	7	12.5^{d}	41	73.2^{a}	8	14.3^{c}			56
	D	3	7.7^{d}	22	56.4^{a}	13	33.3^{b}	1	2.6^{d}	39
	E			28	34.1^{b}	48	58.5^{a}	6	7.3^{d}	82
	F			5	10.6^{c}	30	63.8^{a}	12	25.5^{c}	47
	G					26	37.7^{b}	43	62.3^{b}	69
	H					1	1.6^{c}	62	98.4^{a}	63

N*: Number of individuals;* ***Letters (a, b, c, d)****; If the percentages of the stages given separately for each gender and age group have completely different letters, the stages in question are significantly different. For example, the stage with the letter a differs significantly from the stage with the letter b, c, d.*

Table 3. *Right mandibular third molar specific distribution of number of individuals for each age group according to sex and developmental stage*

	Stage	Group 1		Group 2		Group 3		Group 4		*Total*
		N	%	N	%	N	%	N	%	N
Male	0	13	100.0^{a}							13
	A	19	95.0^{a}	1	5.0^{c}					20
	B	29	74.4^{b}	10	2.6^{b}					39
	C	5	20.8^{b}	19	79.2^{a}					24
	D			8	88.9^{a}	1	11.1^{c}			9
	E			10	41.7^{b}	12	50.0^{ab}	2	8.3^{d}	24
	F			2	9.5^{c}	14	66.7^{a}	5	23.8^{c}	21
	G					9	37.5^{b}	15	62.5^{b}	24
	H					1	2.9^{c}	33	97.1^{a}	34
Female	0	13	100.0^{a}							13
	A	25	96.2^{a}	1	3.8^{c}					26
	B	29	76.3^{b}	8	21.1^{b}	1	2.6^{c}			38
	C	5	14.7^{c}	22	64.7^{a}	7	20.6^{b}			34
	D	1	3.6^{c}	17	60.7^{a}	9	32.1^{b}	1	3.6^{d}	28
	E			18	34.0^{b}	32	60.4^{a}	3	5.7^{d}	53
	F			4	10.8^{c}	23	62.2^{a}	10	27.0^{c}	37
	G					17	37.8^{b}	28	62.2^{b}	45
	H							27	100.0^{a}	27
Total	0	26	100.0^{a}							26
	A	44	95.7^{a}	2	4.3^{c}					46
	B	58	75.3^{b}	18	23.4^{b}	1	1.3^{c}			77
	C	10	17.2^{c}	41	70.7^{a}	7	12.1^{c}			58
	D	1	2.7^{c}	25	67.6^{a}	10	27.0^{b}	1	2.7^{d}	37
	E			28	36.4^{b}	44	57.1^{a}	5	6.5^{d}	77
	F			6	10.3^{c}	37	63.8^{a}	15	25.9^{c}	58
	G					26	37.7^{b}	43	62.3^{b}	69

N*: Number of individuals;* ***Letters (a, b, c, d)****; If the percentages of the stages given separately for each gender and age group have completely different letters, the stages in question are significantly different. For example, the stage with the letter a differs significantly from the stage with the letter b.*

Table 4. *Distribution of each age group according to sex and developmental stage for both right and left mandibular third molars*

	Stage	Group 1		Group 2		Group 3		Group 4		Total
		N	%	N	%	N	%	N	%	N
Male	0	30	96,8[a]	1	3,2[d]					31
	A	35	92,1[a]	3	7,9[d]					38
	B	57	73,1[b]	21	26,9[c]					78
	C	9	19,1[c]	38	80,9[a]					47
	D	1	5,6[d]	14	77,8[a]	3	16,7[c]			18
	E			20	41,7[b]	24	50,0[a]	4	8,3[d]	48
	F			3	7,5[d]	27	67,5[a]	10	25,0[c]	40
	G					18	37,5[ab]	30	62,5[b]	48
	H					2	2,9[d]	66	97,1[a]	68
Female	0	27	100,0[a]							27
	A	52	94,5[a]	3	5,5[c]					55
	B	56	76,7[b]	16	21,9[b]	1	1,4[c]			73
	C	8	11,9[c]	44	65,7[a]	15	22,4[b]			67
	D	3	5,2[c]	33	56,9[a]	20	34,5[b]	2	3,4[c]	58
	E			36	32,4[b]	68	61,3[a]	7	6,3[c]	111
	F			8	12,3[c]	40	61,5[a]	17	26,2[b]	65
	G					34	37,8[b]	56	62,2[a]	90
	H							56	100,0[a]	56
Total	0	57	98,3[a]	1	1,7[c]					58
	A	87	93,5[a]	6	6,5[c]					93
	B	113	74,8[b]	37	24,5[b]	1	0,7[c]			151
	C	17	14,9[c]	82	71,9[a]	15	13,2[c]			114
	D	4	5,3[c]	47	61,8[a]	23	30,3[b]	2	2,6[d]	76
	E			56	35,2[b]	92	57,9[a]	11	6,9[d]	159
	F			11	10,5[c]	67	63,8[a]	27	25,7[c]	105
	G					52	37,7[b]	86	62,3[b]	138
	H					2	1,6[c]	122	98,4[a]	124

N: *Number of individuals;* ***Letters (a, b, c, d)****; If the percentages of the stages given separately for each gender and age group have completely different letters, the stages in question are significantly different. For example, the stage with the letter a differs significantly from the stage with the letter b.*

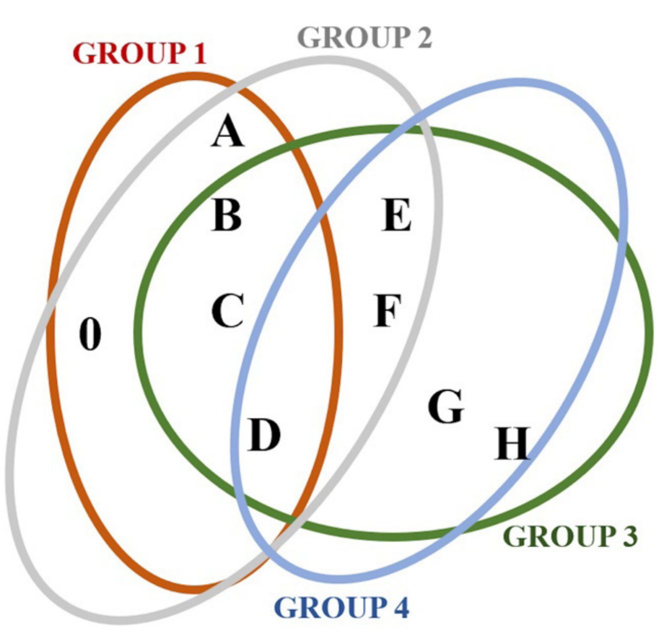

Figure 2. *Expression of Demirjian stages of third molar development from 0 to H in sets of specific age groups investigated in this present study. Red set refers to Group 1, gray set refers to Group 2, green set refers to Group 3 and blue set refers to Group 4.*

Table 5. *Presentation of developmental stages compliance between right and left mandibular third molar*

			LEFT third molar									
			0	A	B	C	D	E	F	G	H	Total
Male	RIGHT third molar	0	13	0	0	0	0	0	0	0	0	13
		A	3	15	2	0	0	0	0	0	0	20
		B	2	3	32	2	0	0	0	0	0	39
		C	0	0	5	18	1	0	0	0	0	24
		D	0	0	0	3	6	0	0	0	0	9
		E	0	0	0	0	2	21	1	0	0	24
		F	0	0	0	0	0	3	18	0	0	21
		G	0	0	0	0	0	0	0	23	1	24
		H	0	0	0	0	0	0	0	1	33	34
	Total		18	18	39	23	9	24	19	24	34	208
			0	A	B	C	D	E	F	G	H	Total
Female	RIGHT third molar	0	9	4	0	0	0	0	0	0	0	13
		A	5	19	2	0	0	0	0	0	0	26
		B	0	4	31	3	0	0	0	0	0	38
		C	0	2	2	24	6	0	0	0	0	34
		D	0	0	0	3	19	6	0	0	0	28
		E	0	0	0	3	5	41	4	0	0	53
		F	0	0	0	0	0	10	21	6	0	37
		G	0	0	0	0	0	1	3	38	3	45
		H	0	0	0	0	0	0	0	1	26	27
	Total		14	29	35	33	30	58	28	45	29	301
			0	A	B	C	D	E	F	G	H	Total
TOTAL	RIGHT third molar	0	22	4	0	0	0	0	0	0	0	26
		A	8	34	4	0	0	0	0	0	0	46
		B	2	7	63	5	0	0	0	0	0	77
		C	0	2	7	42	7	0	0	0	0	58
		D	0	0	0	6	25	6	0	0	0	37
		E	0	0	0	3	7	62	5	0	0	77
		F	0	0	0	0	0	13	39	6	0	58
		G	0	0	0	0	0	1	3	61	4	69
		H	0	0	0	0	0	0	0	2	59	61
	Total		32	47	74	56	39	82	47	69	63	509

4.DISCUSSION

The present study specifically evaluated the potential Demirjian's method for identification of an individual who has attained medicolegally significant ages of 12, 15 and 18 years in a Turkish subpopulation. Those three age limits are defined by Turkish Penal Code and children under the age of 12 have no legal responsibility. Any person who has not reached the age of 18 is a minor and if a minor is older than 12, but younger than 15, evaluation of the ability to appreciate the legal meaning and capability to control behavior is required. There are also different regulations concerning individuals older than 15 but younger than 18 years in Turkish Penal Code. This is also similar in Andorra, Belgium, Hungary, Ireland, Netherlands, San Marino, and Scotland where children can be held criminally liable from the age of 12. Another relevant threshold, age of 15 is also critical in Czech Republic, Iceland, Norway, Slovakia, and Sweden (9). Therefore, the age limits of 12, 15 and 18 years have legal significance both in Turkey and in some European countries as well. Regarding these specific thresholds, four groups were formed in our study investigating individuals under the age of 12, aged between 12 to 15, 15 to 18 and aged over 18 years.

Considering 3M mineralization profile of 509 individuals presented in this study, crypt formation (stage 0) started at age of 6 in males and 7 for females for both sides of the mandible. This is in accordance with the previous findings of other studies conducted in Turkish population who reported that reported that the crypt formation at the mandibular 3M at the age of 7 (10,11). Our results for the average age for closure of the root apex (stage H) was between 20.38 to 20.44 for males and 20.66 to 20.74 for females, in accordance with Orhan et al. who found this average as 20.1 years (10). As suggested by Lewis and Senn, ancestral population specificity is an important criterion for an accurate and reliable age estimation (4). Moreover, Orhan et al. reported that in Turkish population all stages of 3M development occurred at an earlier age than the Japanese, South African, German, and Spanish populations (10). Furthermore, the results of the age estimation studies conducted in the same population may also differ. These differences were attributed not only to geographic and ethnic variations, but also to methodology and dissimilarity of observers as well (12).

Regarding our results on the specific age groups with legal significance, probability of stages 0 and A were found to be higher than stage B in Group 1 with a statistical significance. Only one mandibular 3M (1.7%) with stage 0 was observed in Group 2. Therefore, an individual with stage 0 was high likely to be under the age of 12 and in Group 1. This is in accordance with Orhan et al. who reported that crypt formation was not observed after 10 and 11 years, for males and for females respectively (10). Additionally, in the present study root formation (stages E, F, G, H) was not observed in individuals under age 12 as well. Considering Group 2, probability of stages C and D were found to be higher with a statistical significance. Kasper et al. also suggested that an individual with a mandibular 3M presenting stage B or above should be greater than 12 years of age (13). In Group 2, stages G and H were not observed whereas only 11 teeth presented stage F (10.5%). Regarding Group 3, probability of stage E and F were found to be higher with a statistical significance, which may indicate that an individual with these stages is high likely to be older than age 15. Additionally, in males, all mineralization processes regarding crown development of 3M were completed and stages 0, A, B and C was not observed in this group. For females, the crown development seemed to continue as the stages B, C were observed in individuals between 15 and 18 years. This finding is in accordance with the findings of previous studies reporting that 3M of males matured earlier than those of females (3, 13, 14).

As development of stage H is related to the chronologic age of 18, this stage was found to be statistically high in Group 4, in accordance with the results of previous studies (10, 12, 15, 16). For the individuals of 18 and over, only 2 mandibular 3M (2.6%) presented stage D and the rest were stage E and above. Various studies conducted in different populations related the absence of stages from A to E with the prediction of age 18 (10, 12, 14-16). In the present study, stages 0, A, B, C were not observed in Group 4. Regarding minimum ages, Kanchan et al. (17) reported that individuals with stage G and H were over 18 years of age in Indian population. However, in the present study, the minimum age for stage G was 15 for males and females, which was in accordance with Cantekin et al. (11) who also investigated 3M mineralization in Turkish population and reported this age as 15.3 for males and 15.1 for females, pointing out the population specific variations.

Another important consideration of the present study was differences in the right and left readings. Regarding the results of 3M mineralization for males; D, E stages were reached earlier, and stage F was reached later on the left side than the right side. Interestingly, the scores were not the same for right and left readings for "all" stages as presented in Table 5 with the most variation in readings of stages B, C, E and G as two stages below and one stage above the concordance. Such variations were also reported by Ashifa et al. (3) and Kasper et al. (13) who both recommended independent evaluation of both sides in staging 3M mineralization. Therefore, considering aforementioned age limits in various penal codes and the absence of some stages in some age groups, we also recommend evaluation of every single tooth for age estimation.

Similar to our approach, Kanchan et al. also investigated the potential of Demirjian method to provide cut – off points to age of 16 and 18, which have a legal significance in Indian governing law (17). They have concluded that Demirjian's stages of third molar maturation can be used to ascertain whether an individual has attained those medicolegally significant ages. Regarding the results of our study, we also recommend use of Demirjian method in assessment of groups investigating specific ages with legal significance. Considering the previous studies with additional skeletal indicators such as spheno-occipital synchondrosis and medial clavicle with 3M mineralization evaluation (18, 19), use of multifactorial approach can also be suggested for the enhanced analysis of those specific age groups for future studies.

5.CONCLUSION

The present investigation provides representative data regarding the discrimination of specific groups with age thresholds of 12, 15, and 18 used by Turkish and various European penal codes. Our results indicate that independent evaluation of both sides and consideration of sexual dimorphism are important in estimating age from the 3M mineralization. Considering growing diversity and the foreign-born population in various countries, collaborated age estimation studies may reveal more specific data for 3M development differences which can help ethnicity-specific evaluation of medicolegally relevant subadult age groups according to governing law.

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REFERENCES

[1] Yan J, Lou X, Xie L, Yu D , Shen G, Wang Y. Assessment of dental age of children aged 3.5 to 16.9 years using Demirjian's method: A meta-analysis based on 26 studies. PLoS One 2013; 8 (12) :e84672. DOI: 10.1371/journal.pone.0084672

[2] Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973; 45 (2):211-227.

[3] Ashifa N, Parakh MK, Ulaganambi S. Estimation of Age Using Third Molar Development: A Radiological Cross-Sectional Study. Am J Forensic Med Pathol. 2020;41 (2):115-118. DOI: 10.1097/PAF.000.000.0000000540

[4] Lewis JM, Senn DR. Dental age estimation utilizing third molar development: A review of principles, methods, and population studies used in the United States. Forensic Sci Int. 2010; 201(1-3):79-83. DOI: 10.1016/j.forsciint.2010.04.042

[5] Bérgamo AL dQC, Sakamoto HE, Alves da Silva RH Dental Age Estimation Methods in Forensic Dentistry: Literature Review. Forensic Sci Today. 2016; 2(1):4-9. DOI: 10.17352/fst.000005

[6] Olze A, Taniguchi M, Schmeling A, Zhu BL, Yamada Y, Maeda H, Geserick G. Studies on the chronology of third molar mineralization in a Japanese population. Leg Med (Tokyo). 2004;6 (2):73-79. DOI: 10.17352/fst.000005

[7] Saka NE, Budak, H, Temel G. Forensic Psychiatry Practice in Turkey. Sabuncuoglu Serefeddin Health Science 2020; 2(1): 31-39. DOI: 52641/655045

[8] Büken B, Safak AA, Yazici B, Büken E, Mayda AS. Is the assessment of bone age by the Greulich-Pyle method reliable at forensic age estimation for Turkish children? Forensic Sci Int. 2007; 173 (2-3):146-153. DOI: 10.1016/j.forsciint.2007.02.023

[9] Kvaal SI, Kolltveit KM, Thomsen IO, Solheim T. Age estimation of adults from dental radiographs. Forensic Sci Int. 1995;74 (3):175-185. DOI: 10.1016/0379-0738(95)01760-G

[10] Orhan K, Ozer L, Orhan AI, Dogan S, Paksoy CS. Radiographic evaluation of third molar development in relation to chronological age among Turkish children and youth. Forensic Sci Int. 2007;165(1):46-51. DOI: 10.1016/j.forsciint.2006.02.046

[11] Cantekin K, Yilmaz Y, Demirci T, Celikoglu M. Morphologic analysis of third-molar mineralization for eastern Turkish

children and youth. J Forensic Sci. 2012;57(2):531-534. DOI: 10.1111/j.1556-4029.2011.02011.x

[12] Sisman Y, Uysal T, Yagmur F, Ramoglu SI. Third-molar development in relation to chronologic age in Turkish children and young adults. Angle Orthod. 2007;77(6):1040-1045. DOI: 10.2319/101906-430.1

[13] Kasper KA, Austin D, Kvanli AH, Rios TR, Senn DR. Reliability of third molar development for age estimation in a Texas Hispanic population: A comparison study. J Forensic Sci. 2009;54(3):651-657. DOI: 10.1111/j.1556-4029.2009.01031.x

[14] Naik SB, Patil SN, Kamble SD, Mowade T, Motghare P. Reliability of third molar development for age estimation by radiographic examination (Demirjian's Method). J Clin Diagn Res. 2014;8(5):25-28. DOI: 10.7860/JCDR/2014/8160.4361

[15] Maled V, Vishwanath SB. The chronology of third molar mineralization by digital orthopantomography. J Forensic Leg Med. 2016;43:70-75. DOI: 0.1016/j.jflm.2016.07.010

[16] Prieto JL, Barbería E, Ortega R, Magaña C. Evaluation of chronological age based on third molar development in the Spanish population. Int J Legal Med. 2005;119(6):349-354. DOI: 10.1007/s00414.005.0530-3

[17] Kanchan T, Chugh V, Chugh A, Meshram V, Shedge R, Patnana AK, Krishan K. Age estimation using third molar maturation based on Demirjian's criteria. Leg Med (Tokyo) 2021; 53:101959. DOI: 10.1016/j.legalmed.2021.101959

[18] Demirturk Kocasarac H, Sinanoglu A, Noujeim M, Helvacioglu Yigit D, Baydemir C. Radiologic assessment of third molar tooth and spheno-occipital synchondrosis for age estimation: a multiple regression analysis study. Int J Legal Med. 2016;130(3):799-808. DOI: 10.1007/s00414.015.1298-8

[19] Bassed RB, Briggs C, Drummer OH. Age estimation using CT imaging of the third molar tooth, the medial clavicular epiphysis, and the spheno-occipital synchondrosis: A multifactorial approach. Forensic Sci Int. 2011;212(1-3):273.1-5. DOI: 10.1016/j.forsciint.2011.06.007

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