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Ascertaining the validity of a modified survey method for dental age estimations of Malaysian Malay and Chinese juveniles

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ABSTRACT

We investigated the suitability of dental age estimation surveys based on modified Chaillet and Demirjian's method using artificial multilayer perceptron neural network (ANN) for Malaysian Malays and Chinese juveniles. A total of 199 dental panoramic tomographs of Malays and Chinese ranging in age from 5.00 to 17.99 years old were evaluated. The

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difference between chronological age (CA) and dental age from the maturity score (DA) was computed, as well as the mean and standard deviation. Comparison of the estimated DA with CA showed that DA for Malays was significantly overestimated by 0.42 ± 0.91 years (paired t-test, $p < 0.05$) and for Chinese was marginally overestimated by 0.02 ± 0.68 years (paired t-test, $p \geq 0.05$). This shows that DA estimation by using the modified survey of ANN does not differ significantly from CA for the Chinese but for Malays (especially females) a difference was noted.

Keywords: Dental age estimation, dental panoramic tomographs, Malaysian Malay, Malaysian Chinese, Chaillet and Demirjian's method, Artificial Neural Network.

Introduction

In Malaysia, registration of birth is legally enforced. However, there are countries that do not have such laws. Their lack of an organised birth record system leads to the act of false documentation to substantiate the claim of one's age, especially doubtful age of immigrants[1]. Age estimation is also mandatory for the identification of the deceased in mass disasters. Here a thorough methodical approach of preliminary evaluation, post-mortem examination, ante-mortem investigation, and comparison using available dental data are utilised to ensure proper identifications[2-7]. In addition, relevant treatment can be instituted in endocrinology, paediatric dentistry and orthodontics when the age is exactly known[8].

The dental panoramic tomographs (DPTs) proved to be simple, reliable and less invasive in determining the dental age estimation of an individual. A system was established based on tooth development stages A to H [9, 10], that is from the beginning of the cusp calcification to the final matured form with root completion. This system of tooth maturity can therefore be standardised as it passes through the same stages in all individuals. These stages can be easily determined, easily correlated and the scores calculated. It must be stated here that this method is only applicable where the stages are indicated based on the maturity (shape) and not by the size or absolute length measurement. The final score for each tooth is distinct and the total value of the scores for all teeth is 100. Different tooth maturity scores are assigned to girls and

boys as gender differences were noticed during age assessment[9, 10].

Chaillet and Demirjian's method system was widely used with regard to the dental age estimation but some researchers needed to modify the method for the local populations[11]. Therefore, Bunyarit et al. did a study to modify the Chaillet and Demirjian's method using Artificial Multilayer Perceptron Neural Network (ANN) to be used for estimating age of Malays and Chinese in Malaysia[12-14]. To ensure the validity and reliability of this modified survey method, a study was conducted to find out whether the dental age (DA) estimation method of Bunyarit et al. can be employed with certainty for Malaysian Malays and Chinese. In further understanding the study, the difference between dental age (DA) and chronological age(CA) was simplified as within 6 months, within 1 year and more than 1 year.

Materials and methods

A retrospective study was conducted using dental panoramic tomographs (DPTs) obtained from the dental records of patients who were treated at faculties of dentistry at MAHSA University and National University of Malaysia (UKM). Institutional ethical approval was obtained prior to this study (RMC/EC30/2021). Demographic characteristics such as ethnicity, sex, age, date of birth, date of radiograph were compiled. The primary inclusion criteria were that only good quality DPTs displaying various stages of dental development of a complete dentition on the left side of the mandible was selected. There must be proper details of the date of scanning exposure and a definite date of birth of the individual. Whereas exclusion criteria were when DPTs had bilateral missing teeth, evidence of developmental disorders, fractures, cysts and neoplasms. If the DPTs had patients under orthodontic care or inaccurate patient records, they were automatically excluded from the study[13, 14]. Sample size of the study was calculated using Sample Size Calculator v2.0 based on articles by Bunyarit et al.[14] (sample range of 100-1861) and Bunyarit et al.[13] (sample range of 99-1798) [16-20] . It was accepted that 10% would have missing data, significance level was at 0.05, power of 0.8 and precision of 10%. Therefore, sample size for Malay and Chinese was 100 for each ethnicity. In this study, the sample size of 199 DPTs (92 Malay and 107 Chinese patients aged from 5.00-17.99 years) was obtained in order to ensure a statistically sound representation for both ethnicities. Tooth development

was recorded using a score chart adapted from Chaillet and Dermijian's ten developmental stages, as previously described[13-15]. This study used a non-probability (purposed) sampling.

Chronological age estimation

The chronological age estimation was calculated from the date of DPTs taken to the date of birth divided with 365.25 to have the exact number in decimal years. The decimal age formed the basis for subsequent statistical calculation. With this categorization by decimal years, subjects were divided into 13 groups of 5.00-17.99 years[13, 14].

Dental age estimation

Dental age estimations were obtained by referring to the lower left part of the mandible, the DPTs was interpreted according to the stages of tooth development (Figure 1)[21] present, and the score calculated according to Chaillet and Demirjian's 8-teeth method and polynomial functions. Each stage is represented by its corresponding biologically weighted score which was then summed up to obtain the maturity score (Table 1)[15]. Finally the maturity score is referred to the table of scores calculated with new formulae using ANN (Table 2a and 2b) [13, 14]. All the data of CA and DA obtained was analysed using BMI SPSS 26.0 to study the mean and standard deviation of CA, DA and the difference between CA and DA.

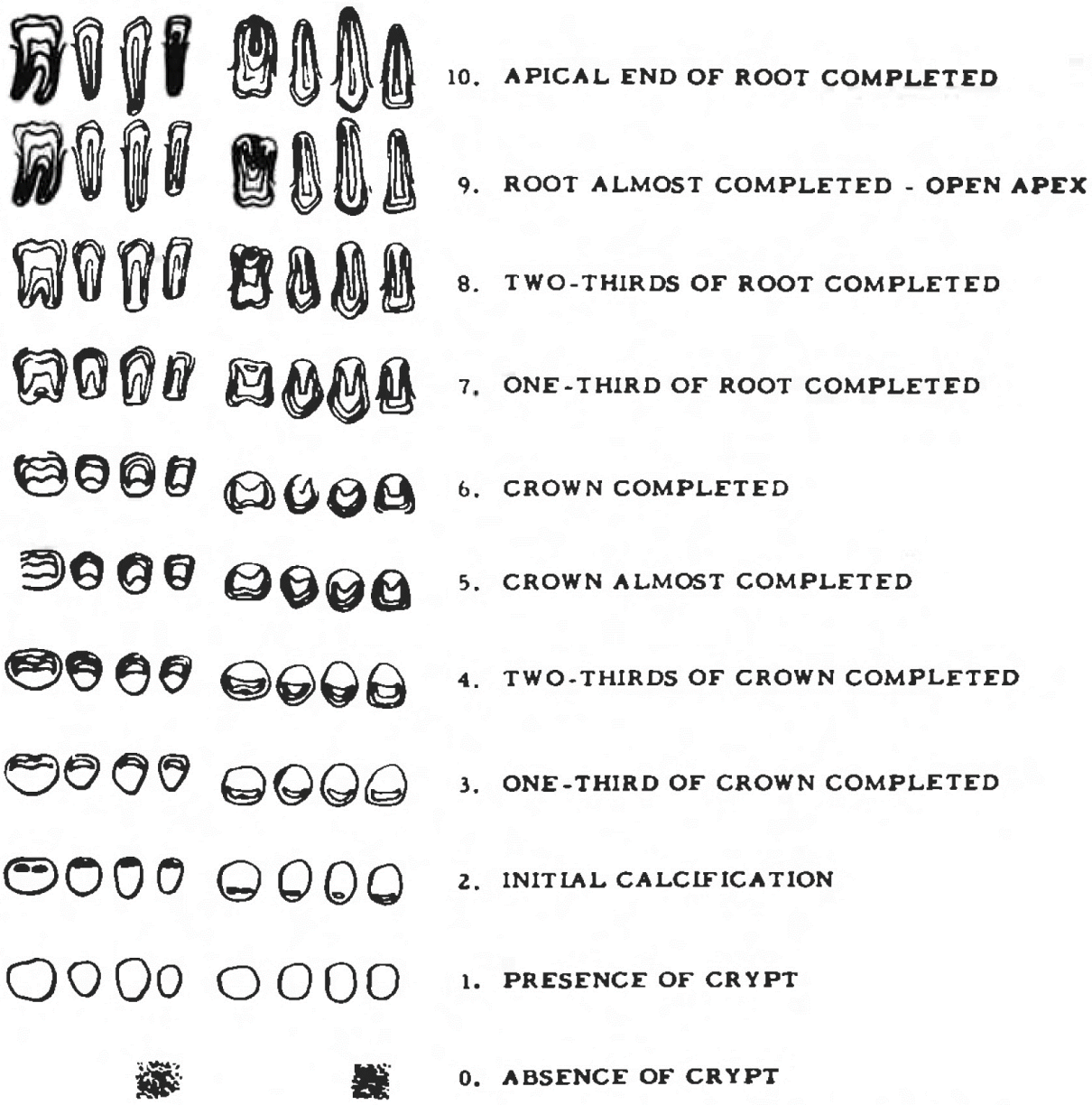

FIGURE 1. Stages of development of mandibular and maxillary teeth.

Figure 1 - The developmental stages of each tooth according to Nolla[21].

Table 1 - Specific weighted scores, standardised to 100, for girls and boys for each stage and left mandibular teeth -Chaillet and Demerjian's 8-teeth method and polynomial functions[15].

Stages	Teeth							
Girls	31	32	33	34	35	36	37	38
0								6.40
1							2.57	7.74
2					2.43			8.92
3				2.56	3.43		2.65	9.31
4			2.55	3.54	3.83		4.10	10.22
5	2.58	2.65	3.15	5.09	5.75	2.58	6.51	11.04
6	3.10	4.54	5.40	6.31	6.81	3.25	8.00	12.65
7	5.02	5.40	7.19	8.09	8.70	4.25	9.13	13.77
8	6.66	7.02	9.22	9.82	10.80	6.88	11.00	14.45
9	10.61	10.89	11.99	12.29	12.79	10.94	13.84	16.65
Boys	31	32	33	34	35	36	37	38
0							1.70	6.19
1					1.69		2.98	7.64
2				1.70	2.27		3.41	8.28
3			1.70	1.98	3.41		4.74	8.86
4			2.67	3.52	3.41		4.88	9.89
5	2.31	2.55	4.34	5.19	5.59	2.13	6.69	11.17
6	4.35	4.71	6.14	6.47	6.96	3.73	7.89	12.25
7	5.16	5.75	7.59	8.18	8.68	4.94	9.08	13.66
8	6.56	6.97	9.52	9.84	10.64	7.00	11.13	14.07
9	10.68	10.91	12.56	12.57	13.11	11.22	13.63	15.32

*****The numbers 31 to 37 (FDI system) represent the permanent lower left first incisor until the permanent lower left second molar; Stages: 0 to 4 = crown calcification; 5 to 8 = root calcification; 9 = apex closure.

Table 2(a) - Dental age maturity scores for Malaysian Malay boys and girls based on a calculated formulae using ANN by Bunyarit et al. [14]

Age	Boy	Girl	Age	Boy	Girl	Age	Boy	Girl
5	26.16	24.42	**10.1**	66.24	68.68	**15.2**	93.85	92.72
5.1	26.62	24.91	**10.2**	67.13	69.56	**15.3**	94.12	92.94
5.2	27.09	25.42	**10.3**	68	70.41	**15.4**	94.38	93.14
5.3	27.58	25.95	**10.4**	68.85	71.25	**15.5**	94.63	93.35
5.4	28.08	26.49	**10.5**	69.7	72.06	**15.6**	94.88	93.55
5.5	28.59	27.06	**10.6**	70.53	72.86	**15.7**	95.12	93.74
5.6	29.12	27.64	**10.7**	71.35	73.63	**15.8**	95.36	93.93
5.7	29.66	28.24	**10.8**	72.15	74.39	**15.9**	95.59	94.12
5.8	30.22	28.87	**10.9**	72.93	75.12	**16**	95.82	94.3
5.9	30.8	29.51	**11**	73.71	75.84	**16.1**	96.04	94.49
6	31.39	30.17	**11.1**	74.46	76.53	**16.2**	96.26	94.66
6.1	32	30.85	**11.2**	75.21	77.21	**16.3**	96.47	94.84
6.2	32.62	31.56	**11.3**	75.93	77.86	**16.4**	96.68	95.01
6.3	33.27	32.28	**11.4**	76.64	78.5	**16.5**	96.88	95.17
6.4	33.92	33.03	**11.5**	77.34	79.12	**16.6**	97.08	95.34
6.5	34.6	33.8	**11.6**	78.01	79.72	**16.7**	97.28	95.5
6.6	35.29	34.59	**11.7**	78.68	80.3	**16.8**	97.47	95.66
6.7	36	35.4	**11.8**	79.32	80.86	**16.9**	97.65	95.81
6.8	36.72	36.23	**11.9**	79.96	81.41	**17**	97.83	95.97
6.9	37.47	37.08	**12**	80.57	81.94	**17.1**	98.01	96.12
7	38.22	37.95	**12.1**	81.17	82.45	**17.2**	98.19	96.27
7.1	39	38.84	**12.2**	81.76	82.95	**17.3**	98.36	96.41
7.2	39.79	39.75	**12.3**	82.33	83.43	**17.4**	98.53	96.55
7.3	40.59	40.67	**12.4**	82.89	83.9	**17.5**	98.69	96.69
7.4	41.41	41.61	**12.5**	83.43	84.35	**17.6**	98.85	96.83
7.5	42.25	42.57	**12.6**	83.96	84.79	**17.7**	99.01	96.97
7.6	43.1	43.55	**12.7**	84.48	85.21	**17.8**	99.17	97.1
7.7	43.96	44.54	**12.8**	84.98	85.63	**17.9**	99.32	97.24
7.8	44.83	45.54	**12.9**	85.47	86.03	**18**	99.47	97.37
7.9	45.72	46.55	**13**	85.95	86.42			
8	46.62	47.57	**13.1**	86.41	86.79			
8.1	47.53	48.6	**13.2**	86.87	87.16			
8.2	48.44	49.64	**13.3**	87.31	87.51			
8.3	49.37	50.68	**13.4**	87.74	87.86			
8.4	50.3	51.73	**13.5**	88.15	88.2			
8.5	51.24	52.78	**13.6**	88.56	88.52			
8.6	52.19	53.83	**13.7**	88.96	88.84			
8.7	53.14	54.88	**13.8**	89.35	89.15			
8.8	54.09	55.93	**13.9**	89.72	89.45			
8.9	55.04	56.98	**14**	90.09	89.74			
9	56	58.01	**14.1**	90.45	90.02			
9.1	56.95	59.04	**14.2**	90.8	90.3			
9.2	57.9	60.07	**14.3**	91.14	90.57			
9.3	58.86	61.08	**14.4**	91.47	90.83			
9.4	59.8	62.08	**14.5**	91.79	91.09			
9.5	60.74	63.07	**14.6**	92.11	91.34			
9.6	61.68	64.05	**14.7**	92.42	91.58			
9.7	62.61	65.01	**14.8**	92.72	91.82			
9.8	63.53	65.95	**14.9**	93.01	92.05			
9.9	64.45	66.88	**15**	93.3	92.28			
10	65.35	67.79	**15.1**	93.58	92.5			

Table 2(b) - Dental age maturity scores for Malaysian Chinese boys and girls based on a calculated formulae using ANN by Bunyarit et al. [13]

Age	Males	Females	Age	Males	Females	Age	Males	Females
5	27.51	25.7	**10.1**	66.8	69.46	**15.2**	94.72	93.82
5.1	27.95	26.26	**10.2**	67.7	70.31	**15.3**	94.93	93.97
5.2	28.41	26.84	**10.3**	68.58	71.14	**15.4**	95.13	94.12
5.3	28.88	27.44	**10.4**	69.46	71.96	**15.5**	95.33	94.25
5.4	29.37	28.06	**10.5**	70.32	72.77	**15.6**	95.51	94.38
5.5	29.88	28.7	**10.6**	71.18	73.56	**15.7**	95.69	94.5
5.6	30.39	29.36	**10.7**	72.02	74.34	**15.8**	95.86	94.62
5.7	30.93	30.04	**10.8**	72.85	75.11	**15.9**	96.02	94.73
5.8	31.48	30.73	**10.9**	73.67	75.86	**16**	96.18	94.83
5.9	32.04	31.45	**11**	74.47	76.59	**16.1**	96.33	94.93
6	32.63	32.18	**11.1**	75.26	77.31	**16.2**	96.47	95.03
6.1	33.22	32.93	**11.2**	76.04	78.02	**16.3**	96.6	95.11
6.2	33.84	33.7	**11.3**	76.8	78.71	**16.4**	96.74	95.2
6.3	34.47	34.48	**11.4**	77.54	79.38	**16.5**	96.86	95.28
6.4	35.11	35.28	**11.5**	78.28	80.04	**16.6**	96.98	95.35
6.5	35.77	36.1	**11.6**	78.99	80.68	**16.7**	97.09	95.42
6.6	36.45	36.93	**11.7**	79.69	81.31	**16.8**	97.2	95.49
6.7	37.15	37.78	**11.8**	80.37	81.91	**16.9**	97.31	95.55
6.8	37.86	38.65	**11.9**	81.04	82.51	**17**	97.4	95.61
6.9	38.58	39.52	**12**	81.69	83.08	**17.1**	97.5	95.67
7	39.32	40.41	**12.1**	82.33	83.64	**17.2**	97.59	95.72
7.1	40.08	41.31	**12.2**	82.95	84.18	**17.3**	97.68	95.77
7.2	40.85	42.22	**12.3**	83.55	84.71	**17.4**	97.76	95.81
7.3	41.63	43.14	**12.4**	84.14	85.22	**17.5**	97.84	95.86
7.4	42.43	44.08	**12.5**	84.71	85.71	**17.6**	97.91	95.9
7.5	43.24	45.01	**12.6**	85.26	86.19	**17.7**	97.98	95.94
7.6	44.06	45.96	**12.7**	85.8	86.65	**17.8**	98.05	95.97
7.7	44.9	46.91	**12.8**	86.32	87.1	**17.9**	98.11	96
7.8	45.75	47.87	**12.9**	86.83	87.53	**18**	98.17	96.04
7.9	46.61	48.84	**13**	87.32	87.94			
8	47.48	49.8	**13.1**	87.79	88.34			
8.1	48.36	50.77	**13.2**	88.25	88.73			
8.2	49.25	51.74	**13.3**	88.7	89.1			
8.3	50.15	52.72	**13.4**	89.13	89.46			
8.4	51.06	53.69	**13.5**	89.54	89.8			
8.5	51.97	54.66	**13.6**	89.95	90.13			
8.6	52.89	55.63	**13.7**	90.34	90.44			
8.7	53.82	56.6	**13.8**	90.71	90.75			
8.8	54.74	57.56	**13.9**	91.07	91.04			
8.9	55.68	58.52	**14**	91.42	91.31			
9	56.61	59.47	**14.1**	91.76	91.58			
9.1	57.55	60.42	**14.2**	92.08	91.83			
9.2	58.49	61.36	**14.3**	92.4	92.08			
9.3	59.42	62.3	**14.4**	92.7	92.31			
9.4	60.36	63.23	**14.5**	92.99	92.53			
9.5	61.29	64.15	**14.6**	93.26	92.74			
9.6	62.23	65.06	**14.7**	93.53	92.95			
9.7	63.15	65.96	**14.8**	93.79	93.14			
9.8	64.07	66.85	**14.9**	94.04	93.32			
9.9	64.99	67.73	**15**	94.27	93.5			
10	65.9	68.6	**15.1**	94.5	93.66			

Inter-examiner and intra-examiner reliability

It must be stated here that forty DPTs were scored initially for the first time and subsequently scored again after a four-week interval by the same observer to assess intra-examiner reproducibility. This was followed by the third time scoring by another observer to assess inter-examiner repeatability. Reliability in the measurements between the observers were analysed using Intraclass Correlation Coefficient (ICC) for both Malay and Chinese respectively.

Result

Inter- and intra-examiner reliability

Table 3. Inter- and intra-examiner reliability test using Intraclass Correlation Coefficient (ICC).

Reliability test	Interval between measurement	Number of DPTs examined	Single measure	Average measure	ICC
Inter-examiner	4 weeks	40	0.981	0.99	0.990
Intra-examiner	4 weeks	40	0.969	0.984	0.984

The calculated Intraclass Correlation Coefficient (ICC) values for inter- and intra-examiner reliability were 0.990 and 0.984 respectively which were near excellent reliability.

Comparison between estimated DA and CA using the modified Chaillet and Demirjian's data using ANN

A total number of 199 subjects aged 5.00 to 17.99 years, comprising 92 Malays (46 males, 46 females) and 107 Chinese (53 males, 54 females) (Table 4 & 5).

Table 4. Distribution of Malaysian subjects by race.

Gender	Race		Total
	Malay	Chinese	
Male	46	53	99
Female	46	54	100
Total	92	107	199

The distribution of the sample according to gender was almost the same for both races.

Table 5. Distribution of Malaysian Malay and Chinese subjects by age and gender.

Chronological age (years)	Male (%)	Female (%)	Total (%)
5.00-5.99	5(5.05)	3(3.00)	8(4.02)
6.00-6.99	7(7.07)	10(10.00)	17(8.54)
7.00-7.99	6(6.06)	9(9.00)	15(7.54)
8.00-8.99	3(3.03)	9(9.00)	12(6.03)
9.00-9.99	13(13.13)	4(4.00)	17(8.54)
10.00-10.99	13(13.13)	5(5.00)	18(9.04)
11.00-11.99	9(9.09)	10(10.00)	19(9.55)
12.00-12.99	7(7.07)	10(10.00)	17(8.54)
13.00-13.99	10(10.10)	11(11.00)	21(10.55)
14.00-14.99	7(7.07)	10(10.00)	17(8.54)
15.00-15.99	8(8.08)	7(7.00)	15(7.54)
16.00-16.99	5(5.05)	8(8.00)	13(6.53)
17.00-17.99	6(6.06)	4(4.00)	10(5.03)
Total	99(100)	100(100)	199(100)

The distribution of sample by chronological age (in percentage) for males and females was fairly similar across all ages.

Table 6. Comparison between Malay and Chinese males and females.

Race	Gender	N	Mean	SD	95% CI of the Difference		t (df)	*p*-value
					Lower	Upper		
Malay	Male	46	0.33	1.08	0.01	0.65	2.09(45)	0.042*
	Female	46	0.50	0.70	0.29	0.71	4.83 (45)	<0.001*
Chinese	Male	53	-0.02	0.63	-0.20	0.15	-0.26 (52)	0.794
	Female	54	0.05	0.73	-0.15	0.25	0.54 (53)	0.594

*p<0.05, statistically significant

The result of paired t-tests for Malay and Chinese (males and females) is shown in Table 6. Malays of both genders had p-value less than 0.05, whereas the Chinese of both genders had p-value of more than 0.05.

Table 7. Paired t-test to determine if DPTs acquired at different facilities caused biased results.

University	Race	Gender	Paired Differences					t (df)	*p*-value
			N	Mean	SD	95% CI			
						Lower	Upper		
MAHSA	Malay	Male	24	0.40	1.37	-0.18	0.97	1.42 (23)	0.170
		Female	23	0.58	0.85	0.21	0.94	3.24 (22)	0.004*
	Chinese	Male	30	0.00	0.55	-0.20	0.21	0.03 (29)	0.979
		Female	28	-0.08	0.70	-0.36	0.19	-0.63 (27)	0.538
UKM	Malay	Male	22	0.26	0.65	-0.02	0.55	1.90 (21)	0.072
		Female	23	0.43	0.53	0.20	0.66	3.90 (22)	0.001*

	Chinese	Male	23	-0.06	0.73	-0.37	0.26	-0.36 (22)	0.719
		Female	26	0.20	0.75	-0.10	0.50	1.37 (25)	0.183

*p<0.05, statistically significant

Paired t-test results separated according to which facility provided the DPTs (MAHSA and UKM). Malay females had p-value less than 0.05; Malay males, Chinese males and females had p-value more than 0.05.

Table 8 (a). The difference between dental age (DA) and chronological age(CA) by range in years.

Difference DA-CA by range (years)		**Frequency**	**Percent (%)**	**Total percent by range (%)**
More than 1 year (younger than CA)	-10.00, -1.01	12	6.03	6.03
Within 1 year (younger than CA)	-1.00, -0.51	16	8.04	8.04
Within 6 months	-0.50, 0.00	46	23.12	56.79
	0.00, 0.50	67	33.67	
Within 1 year (older than CA)	0.51, 1.00	35	17.59	17.59
More than 1 year (older than CA)	1.01, 10.00	23	11.56	11.56
Total		199	100.00	100.00

Table 8 (b). Simplified differences between dental age (DA) and chronological age (CA) by range in years.

Difference DA-CA by range (years)	Percentage (%)
Within 1 year (including within 6 months)	25.63 + (56.79) = 82.42
More than 1 year	17.59
Total	100.00

The above table shows simplified differences between Dental Age and Chronological Age by range in years. 56.79% of the DA-CA was within 6 months and 82.42% varied within 1 year.

Discussion

Estimation of age is one of the main tasks of a forensic practitioner, especially in third world countries, where many births take place in rural settings without the benefit of trained medical personnel. Such births are poorly recorded or more often not recorded at all in terms of exact dates[22]. Certain countries consider 18 years of age as the threshold for being adults [23]. The penalty for criminal offences for juveniles is usually lighter in most countries. However, in some countries, it becomes more challenging when they do have mandatory death penalty for adults as their form of capital punishment [24.25].

In this study, it shows that the dental age estimation (DA) derived from modified Chaillet and Demirjian's maturity score when compared to chronological age (CA) for both Malay males and females were overestimated by 0.33 and 0.50 years respectively. As for Chinese, the estimated DA when compared to CA was underestimated for Chinese males by -0.02 years and overestimated for Chinese females by 0.05 years. By classifying the difference in between the DA and CA for both Malays and Chinese, it was evident that almost 56.79% of the differences were within 6 months and 82.42% varied within 1 year (Table 8(a) and 8(b)).

By doing a paired t-test (Table 6), the p-value for both Malay males and females were <0.05 and p-value for both Chinese male and female were >0.05. Consequently, this showed that DA estimation by employing the modified Chaillet and Demirjian’s data did not differ

significantly from CA for Malaysian Chinese but for Malaysian Malays a difference was noted.

When compared to the previous validity studies done by Bunyarit et al., the differences between the estimated DA and CA for both Malay males and females were overestimated by 0.035 and 0.048 years while for Chinese males and females were underestimated by -0.048 and -0.059 years[13, 14]. As there was a confirmation that for Malays and Chinese the p-values were more than 0.05, both ethnicities (males and females) had no significant differences when comparing the estimated DA and CA.

However, the difference in the result seen in this present study when compared to the validity study of Bunyarit et al. is that the Malay male and female had significant differences in the estimated DA and CA. This might be due to lesser sample size used; 92 for Malay and 107 for Chinese when compared to the previous study which had 1569 for Malay and 1228 for Chinese. The other possible reason could be the changes in the pattern of mineralisation and development of teeth for the current sample. The previous Bunyarit et al. sample were from DPTs recorded between the years 2001 and 2014, while for the present sample were taken from the years 2015 and 2021.

A further paired t-test (Table 7) was done to clarify the p-value whether there was any significant difference in the data for Malay male and female. In doing so, only Malay females from both MAHSA and UKM had p-value <0.05 but for Malay male the p-value became >0.05.

This showed that both sample sources for Malay females had significant differences while for Malay male had no significant difference between the estimated DA and CA. Thus, further study with an increased sample size is required to determine with certainty if Bunyarit et al. research on Chaillet and Demirjian's data using ANN indeed needs to be improved further for Malay females. Moreover, researchers have cautioned that application of two-dimensional imaging modalities (like periapical images, panoramic images) has its limitations. Future research using three-dimensional imaging modalities like cone-beam computed tomography (CBCT) is recommended for better age estimation methods [26].

Conclusion

The modified Chaillet and Demirjian’s method is accurate to be used for dental

age estimation of Malaysian Chinese juveniles, but must be cautiously employed for Malaysian Malay females. This is because this present investigation revealed that differences in estimated DA with CA in Malays was evident in Malay females. Thus, further study with an increased sample size is required to determine with certainty if Bunyarit et al. research on Chaillet and Demirjian's data using ANN needs to be improved further for estimating the dental age of Malay females.

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Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Ritz-Timme S, Cattaneo C, Collins MJ, Waite ER, Schütz HW, Kaatsch HJ, Borrman HI. Age estimation: the state of the art in relation to the specific demands of forensic practise. Int J Legal Med. 2000 May; 113:129-36.

2. Magni P. Identifying the dead after mass disasters is a crucial part of grieving. Here's how forensic experts do it. The Conversation. 2022. https://theconversation.com/identifying-the-dead-after-mass-disasters-is-a-crucial-part-of-grieving-heres-how-forensic-experts-do-it-180616. (last checked 29th June, 2022).

3. Mallya SM, Lam EWN. White and Pharoah's oral radiology- principles and interpretation. 8th ed. Elsevier Ltd, 2018, p 1812-31.

4. Langdon JD. Dental age estimation in a mass disaster. Criminologist. 1972 Jan 1;7(25):33-5.

5. de Boer HH, Blau S, Delabarde T, Hackman L. The role of forensic anthropology in

disaster victim identification (DVI): recent developments and future prospects. For Sci Res. 2019 Oct 2;4(4):303-15.

6. Bassindale T. Mass disasters–Disaster Victim Identification. Retrieved from We Are. 2014.https://theconversation.com/how-dental-records-will-help-identify-bodies-from-mh17-29535. (last checked 29th June, 2022).

7. NSE crash: Identities of three USAS students confirmed using dental records. The Star. https://www.thestar.com.my/news/nation/2022/05/13/nse-crash-identities-of-three-usas-students-confirmed-using-dental-records. (last checked 13th May 2022).

8. Dorfman J. Dental Records Diagnosis and Treatment Planning. Dental EDU. https://dental-edu.com/more/teaching-private-practice/dental-records-diagnosis-treatment-planning/. (last checked 30th June, 2022)

9. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Bio. 1973 May 1:211-27.

10. Demirjian A, Goldstein H. New systems for dental maturity based on seven and four teeth. Annal of Hum Bio. 1976 Jan 1;3(5):411-21.

11. Asab SA, Noor SN, Khamis MF. The accuracy of Demirjian method in dental age estimation of Malay children. Sing Dent J. 2011 Jan 1;32(1):19-27.

12. Bunyarit SS, Jayaraman J, Naidu MK, Poh RY, Danaee M, Nambiar P. Modified method of dental age estimation of Malay juveniles. Leg Med. 2017 Sep 1; 28:45-53.

13. Bunyarit SS, Jayaraman J, Naidu MK, Yuen Ying RP, Nambiar P, Asif MK. Dental age estimation of Malaysian Chinese children and adolescents: Chaillet and Demirjian's method revisited using artificial multilayer perceptron neural network. Aust J For Sci. 2020 Nov 1;52(6):681-98.

14. Bunyarit SS, Nambiar P, Naidu MK, Ying RP, Asif MK. Dental age estimation of Malay children and adolescents: Chaillet and Demirjian's data improved using artificial multilayer perceptron neural network. Ped Dent J. 2021 Aug 1;31(2):176-85.

15. Chaillet N, Demirjian A. Dental maturity in South France: A comparison between Demirjian's method and polynomial functions. J For Sci. 2004 Sep 1;49(5):1059-66.

16. Raosoft (2004) Raosoft Sample Size Calculator. Raosoft, Inc., Seattle. http://www.raosoft.com/samplesize.html

17. Saeed N, Pervaiz MK, Shahbaz MQ. Determination of sample size. Editorial Advisory Board e. 2005;14(3):319-25.

18. Arifin WN. Sample Size Calculator (Version 2.0)[Spreadsheet File]. http://wnarifin.github.io.

19. Naing NN. Determination of sample size. Malay J Med Sci*: MJMS*. 2003 Jul;10(2):84.

20. Naing, NN. A practical guide on determination of sample size in health sciences research. Kelantan: Pustaka Aman Press, 2011.

21. Nolla CM. The development of the permanent teeth. J Dent Child. 1960; 27:254-66.

22. Aggrawal A. Estimation of age in the living: in matters civil and criminal. J Anat 2009 May 11. doi: 10.1111/j.1469-7580.2009.01048.x.

23. Paliwal PK, Sirohiwal BL, Khanagwal VP, Sharma L. and Chawla H. Dilemma in Estimation of Age in a Dwarf. Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology [serial online]. 2011 Vol. 12; No. 1: (January - June 2011).

24. Aggrawal A., Busuttil A. Age Estimation in the living. The Police Surgeon (Journal of The Association of Police Surgeons). 1991; No. 38: Pp 33-36.

25. Asif MK, Ibrahim N, Al-Amery SM, John J, Nambiar P. Juvenile versus adult: A new approach for age estimation from 3- dimensional analyses of the mandibular third molar apices. J For Rad Imag. 2019. Vol19; December: 100347.

26. Gomathi R, Uma Maheswari T N. Predictability of Kvaal's method in dental age estimation. Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology [serial online]. 2021 Vol. 22; No. 2: (July - December 2021).