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Original Article

Western Saudi adolescent age estimation utilising third molar development

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ABSTRACT

Objective: The aim of this study was to establish reference data on third molar morphology/development for age estimation in Western Saudi adolescents, between ages 14 and 23 years of old. **Materials and Methods:** The orthopantomograms of 130 individuals (males and females), were examined, and the stage of third molar development were evaluated. **Results:** Mean ages, standard deviations, and percentile distributions are presented for each stage of development. The mean estimated age for all participants ($n = 130$) was 219.7 months, and this differed significantly ($P < 0.05$) from the mean chronological age (226.5 months). Deviations of predicted age from real age showed 28.5% of all participants had their age estimated within 1 year (±12 months) of their chronological age. Most (43%) had their age underestimated by more than 12 months and the remaining 28.5% had their age overestimated by more than 12 months of their chronological age. Differences in left-right symmetry information of third molars were detected and were higher in the maxilla (92%) than in the mandible (82%). For all molars reaching stage "H" most individuals (males and females) were over the age 18 years of old. Males reach the developmental stages earlier than females. **Conclusion:** Third molar tooth development can be reliably used to generate mean age and the estimated age range for an individual of unknown chronological age. Further studies with large populations are needed for better statistical results.

Key words: Age estimation, chronological age, forensic odontology, third molars, tooth mineralization, Western Saudi Arabia

INTRODUCTION

The estimation of age by applying data from ancestral and population-based studies is an essential part of forensic odontology and is used internationally in many important legal and disaster situations. One of two methods of age estimation are available: the morphological examination of skeletal features, and the radiological examination of the development of third molars.[1] Age estimation are mostly used to assist the medico-legal system in resolving issues regarding age of legal majority for cases involving immigration and prosecution in the criminal and civil courts.[2] Dentition development and eruption is an important indicator of dental age, and may be considered to be the single best physiological indicator of chronological age in children and juveniles.[3,4] This is because tooth mineralization stages are affected much less than bone mineralization stages by the following: variations in nutritional and endocrine status; teeth are less affected by the local environment; and lastly, can be measured over a considerably longer period.[5-7]

Third molars are in many respects the most variable teeth in terms of mineralization and development, and eruption (if it even occurs) is usually between the ages of 14 and 23 years of age.[2,8] Because there are virtually no other biologic indicators available for this specific age interval, estimation of age using the dentition can also be used to judge the sub-adult (juvenile), versus adult status of those who lack age documentation.[9] Hand and wrist methods are no longer applicable in this age group, as the epiphyseal regions have fused and during the same age period other tooth

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development is all, but completed.[9] Concluded that the examination of third molars may provide reasonable accuracy of the likelihood that a person is at least 18 years of age, instead of examination of exact chronological age.[9]

Age estimation resting on tooth development has two fundamental influences, genetic variability and environmental factors. To this end, others have attempted to reduce variability in outcomes by defining genetically similar population sub-sets to provide standard tables that are more applicable to these genetically similar individuals, thereby reducing the effect of one of the two influences on tooth development.[3,4,10] This is a very important approach as reducing variability in estimates provides more robust outcomes that allow the legal systems to rest their decisions upon.[11] Against this backdrop, this study has the primary aim of determining age standards for tooth development between middle teens and early twenties in a Western Saudi Arabian population group.

MATERIALS AND METHODS

The orthopantomograms (OPG's) of a 130 randomly selected healthy individuals (males $n = 48$ and females $n = 82$) from the Pedodontics-Orthodontics clinic were examined. All OPG's were screened for the presence of pathology, anatomical obstructions, and potential radiographic distortion, as these are potential concerns when determining age.[12]

Additional de-identified data were collected from these diagnostic radiographs such as date of birth, date of radiograph (used to calculate age), and gender. Each OPG was de-identified and analyzed individually, and accordingly classified into age groups, using the methods of Mincer *et al*. and evaluated the stage of third molars development (including root development) to estimate the deviation of chronological age from assessed age, in 14-23 year olds.[9] Developmental stages of the teeth, and the score tables from Mincer *et al*. were used to calculate the scores for each tooth. The values were transformed to formulate an estimated dental age for each OPG, and this was compared with the chronologic age at the time of radiography.[9]

All radiographs were reviewed for quality and the presence of all four third molars. The presence of all four molars were necessary as far as possible, to enable determination of left-right symmetry and all OPG's were rated by a single trained examiner.

All data analysis including the calculations was completed using Excel (Version: 2003, Microsoft, Redmont, USA). Detailed statistical analysis was completed using International Business Machines, SPSS Version 19 (IBM, Armonk, NY). Significance of differences between means was assessed using analysis of variance and significance was set at 95%.

RESULTS

Difference between estimated and chronological ages

Overall, the mean estimated age for all participants was 219.7 months, and this differed significantly ($P < 0.05$) from the mean chronological age (226.5 months). Table 1 showed overall, 28.5% of all participants had their age estimated within 1 year (±12 months) of their chronological age. Most (43%) had their age underestimated by more than 12 months, and the remaining (28.5%) had their age overestimated by more than 12 months of their chronological age. However, this potential overestimation of age might have negative implication for immigration adolescence, early adulthood and adult cases and for medical examiner/coroner unidentified individuals in Table 2.

Symmetry

In this sample, the left-right symmetry information was higher in the maxilla (92%) than in the mandible (82%). The overall percentage of concordance, pooling both arches, was high (87%). This implies that wherever possible, information from all available teeth should be included in age determination. Overall, (60%) of cases exhibited the same grade of crown-root formation in the maxilla and the mandible. As third molars in the maxilla develop faster than those in the mandible, this can be seen in Table 3. The development of the right and left side mandible third molars was compared using unpaired *t*-tests. Statistically significant differences between the two sides were not found.

Table 1: Difference between mean estimated ages and mean real ages (in months)

Age	Mean (SD)	*n*
Estimated	219.7 (18.58)*	130
Real	226.5 (39.08)	130

*Paired *t*-test. $P<0.05$ ($P=0.005$). SD: Standard deviation

Table 2: Deviations of predicted age from real age

Deviation from real age (months)	*n* (% of sample)
−12 to +12	37 (28.5)
>13	37 (28.5)
<−13	56 (43)

Age at formation

The mean chronological age for each stage of formation was calculated for both males and females in Table 4. There was not much sex dimorphism in this sample.

Table 3: Cross-tabulation of stages of formation between maxillary and mandibular third molars within individuals

Maxillary stage	Mandibular stage					Total
	D	E	F	G	H	
D	34	6	4	0	0	44
E	8	7	8	0	0	23
F	0	3	17	4	1	25
G	0	2	10	47	3	62
H	0	0	0	43	40	87
Total	42	18	39	98	44	241

Table 4: Mean chronological age (SD) at each stage of crown-root formation

Third molar	D	E	F	G	H
Maxilla					
18					
Male	15.0 (1.68)	15.4 (1.62)	16.5 (1.69)	19.0 (2.18)	21.6 (1.54)
Female	14.5 (1.89)	15.6 (1.34)	16.7 (2.64)	19.5 (1.76)	21.7 (1.35)
28					
Male	14.9 (1.58)	15.8 (2.12)	17.1 (2.06)	18.7 (1.99)	21.6 (1.55)
Female	14.5 (1.97)	15.2 (1.26)	16.1 (1.67)	19.7 (1.97)	21.8 (1.44)
Mandibular					
38					
Male	14.5 (1.40)	14.8 (0.11)	16.7 (1.44)	20.2 (2.00)	22.3 (1.18)
Female	14.3 (1.25)	16.1 (2.53)	17.4 (2.34)	20.5 (2.12)	21.9 (1.02)
48					
Male	14.5 (1.40)	14.8 (0.11)	16.7 (1.44)	19.4 (1.65)	22.3 (1.10)
Female	14.0 (0.83)	15.4 (1.66)	18.0 (2.17)	20.4 (1.77)	22.3 (1.10)

SD: Standard deviation

Prediction at age 18 years

One of the main purposes of age estimation is to answer the simple question of whether a person is above or below the age of 18 years, as this is considered in many countries as the cut-off between adulthood and being considered as a juvenile. With completed mineralization of the maxillary and mandibular third molars at stage H, 98.3% of the individuals that were classified as reaching stage H, were 18 years of age or older.

Using upper right third molar

In this study, data analysis indicated that in the case of the upper right third molar, 23 (28%) females and 20 (41.6%) of males were recorded as reaching stage H [Table 5]. Of all those reaching stage H (n = 43), only 1 (2.3% column total) were not above the age of 18, but 42 (97.6% column total).

Using upper left third molar

In this study, data analysis indicated that in the case of the upper left third molar, 26 (31.7%) females and 21 (43.7%) of males were recorded as reaching stage H [Table 6]. Of all those reaching stage H (n = 47), only 2 (4.2% column total) were not above the age of 18, but 45 (95.7% column total).

Using lower left third molar

In this study, data analysis indicated that in the case of the lower left third molar, 11 (13.4%) females and 10 (20.8%) of males were recorded as reaching stage H [Table 7]. Of all those reaching stage H (n = 21), were all above 18 years old (100%).

Using lower right third molar

In this study, data analysis indicated that in the case

Table 5: Number and percentage of participants over and under the age of 18, by development stage of 3rd molar (upper right wisdom tooth number 18)

Sex	3rd molar (upper right wisdom tooth number 18) (%)						Total
	O	D	E	F	G	H	
Female							
Over 18 years	6 (12.8)	1 (2.1)	0 (0)	1 (2.1)	16 (34.0)	23 (48.9)	47 (100)
Under 18 years	1 (2.9)	12 (34.3)	8 (22.9)	7 (20.0)	7 (20.0)	0 (0)	35 (100)
Total	7 (8.5)	13 (15.9)	8 (9.8)	8 (9.8)	23 (28.0)	23 (28.0)	82 (100)
Male							
Over 18 years	1 (4.2)	0 (0)	0 (0)	1 (4.2)	3 (12.5)	19 (79.2)	24 (100)
Under 18 years	1 (4.2)	9 (37.5)	3 (12.5)	4 (16.7)	6 (25.0)	1 (4.2)	24 (100)
Total	2 (4.2)	9 (18.8)	3 (6.3)	5 (10.4)	9 (18.8)	20 (41.7)	48 (100)
All							
Over 18 years	7 (9.9)	1 (1.4)	0 (0)	2 (2.8)	19 (26.8)	42 (59.2)	71 (100)
Under 18 years	2 (3.4)	21 (35.6)	11 (18.6	11 (18.6)	13 (22.0)	1 (1.7)	59 (100)
Total	9 (6.9)	22 (16.9)	11 (8.5)	13 (10.0)	32 (24.6)	43 (33.1)	130 (100)

of the lower right third molar, 15 (18.2%) females and 14 (29.1%) of males were recorded as reaching stage H [Table 8]. Of all those reaching stage H (n = 29), were all above 18 years old (100%).

DISCUSSION

The variable and protracted formation of third molars in adolescence and into early adulthood has made it

Table 6: Number and percentage of participants over and under the age of 18, by development stage of 3rd molar (upper left wisdom tooth number 28)

Sex	3rd molar (upper left wisdom tooth number 28) (%)						Total
	0	D	E	F	G	H	
Female							
Over 18 years	4 (8.5)	1 (2.1)	0 (.0)	0 (0)	17 (36.2)	25 (53.2)	47 (100.0)
Under 18 years	0 (0)	11 (31.4)	11 (31.4)	6 (17.1)	6 (17.1)	1 (2.9)	35 (100)
Total	4 (4.9)	12 (14.6)	11 (13.4)	6 (7.3)	23 (28.0)	26 (31.7)	82 (100)
Male							
Over 18 years	0 (0)	0 (0)	0 (0)	2 (8.3)	2 (8.3)	20 (83.3)	24 (100)
Under 18 years	1 (4.2)	10 (41.7)	2 (8.3)	4 (16.7)	6 (25.0)	1 (4.2)	24 (100)
Total	1 (2.1)	10 (20.8)	2 (4.2)	6 (12.5	8 (16.7	21 (43.8)	48 (100)
All							
Over 18 years	4 (5.6)	1 (1.4)	0 (0)	2 (2.8)	19 (26.8)	45 (63.4)	71 (100)
Under 18 years	1 (1.7)	21 (35.6)	13 (22.0)	10 (16.9)	12 (20.3)	2 (3.4)	59 (100)
Total	5 (3.8)	22 (16.9)	13 (10.0)	12 (9.2)	31 (23.8)	47 (36.2)	130 (100)

Table 7: Number and percentage of participants over and under the age of 18, by development stage of 3rd molar (lower left wisdom tooth number 38)

Sex	3rd molar (upper left wisdom tooth number 38)					Total
	D	E	F	G	H	
Female						
Over 18 years	0 (0)	1 (2.1)	4 (8.5)	31 (66.0)	11 (23.4)	47 (100.0)
Under 18 years	16 (45.7)	4 (11.4)	7 (20.0)	8 (22.9)	0 (.0)	35 (100.0)
Total	16 (19.5)	5 (6.1)	11 (13.4)	39 (47.6)	11 (13.4)	82 (100.0)
Male						
Over 18 years	0 (0)	0 (0)	0 (0)	14 (58.3)	10 (41.7)	24 (100.0)
Under 18 years	7 (29.2)	2 (8.3)	10 (41.7)	5 (20.8)	0 (.0)	24 (100.0)
Total	7 (14.6)	2 (4.2)	10 (20.8)	19 (39.6)	10 (20.8)	48 (100.0)
All						
Over 18 years	0 (0)	1 (1.4)	4 (5.6)	45 (63.4)	21 (29.6)	71 (100.0)
Under 18 years	23 (39.0)	6 (10.2)	17 (28.8)	13 (22.0)	0 (.0)	59 (100.0)
Total	23 (17.7)	7 (5.4)	21 (16.2)	58 (44.6)	21 (16.2)	130 (100.0)

Table 8: Number and percentage of participants over and under the age of 18, by development stage of 3rd molar (lower right wisdom tooth number 48)

	3rd molar (lower right wisdom tooth number 48)						
Sex	0	D	E	F	G	H	Total
Female							
Over 18 years	3 (6.4)	0 (0)	1 (2.1)	4 (8.5)	24 (51.1)	15 (31.9)	47 (100.0)
Under 18 years	2 (5.7)	12 (34.3)	8 (22.9)	7 (20.0)	5 (14.3)	0 (0)	35 (100.0)
Total	5 (6.1)	12 (14.6)	9 (11.0)	11 (13.4)	29 (35.4)	15 (18.3)	82 (100.0)
Male							
Over 18 years	1 (4.2)	0 (0)	0 (0)	0 (0)	9 (37.5)	14 (58.3)	24 (100.0)
Under 18 years	0 (.0)	7 (29.2)	2 (8.3)	10 (41.7)	5 (20.8)	0 (0)	24 (100.0)
Total	1 (2.1)	7 (14.6)	2 (4.2)	10 (20.8)	14 (29.2)	14 (29.2)	48 (100.0)
All							
Over 18 years	4 (5.6)	0 (0)	1 (1.4)	4 (5.6)	33 (46.5)	29 (40.8)	71 (100.0)
Under 18 years	2 (3.4)	19 (32.2)	10 (16.9)	17 (28.8)	10 (16.9)	0 (0)	59 (100.0)
Total	6 (4.6)	19 (14.6)	11 (8.5)	21 (16.2)	43 (33.1)	29 (22.3)	130 (100.0)

the subject of many studies.[5,9,13-15] Formation is usually between the ages of 14 and 23 years of age,[8] and because there are virtually no other biologic indicators available for this age interval, formation assessment can also be used to judge the sub-adult (juvenile) versus adult status of individuals who lack age documentation.[9] Third molars are the most variable teeth however, interindividual variation exists, and any one individual may have as many as one to all four of their third molars mineralized.[9,16-18] Although the reliability of third molars in age estimation has been evaluated by several research groups, consensus on the usefulness of these teeth has not been reached. As concluded by Mincer *et al*. in their study, the examination of third molars may provide reasonable accuracy for the likelihood that a person is at least, e.g. 18 years old, instead of the estimation of exact chronological age.[9] Consequently, in our assessment, we investigated the probability of Saudi adolescents between 14 and 23 years reaching the age of 18, based on the formation stage of their third molars

Mean ages were calculated for appropriate chronological age, sex dimorphism, and left-right symmetry in third molar development, for both the upper and lower jaws. Statistically our findings were significant ($P < 0.05$), indicating a difference between the mean estimated age and the chronological age of about 7 months. Although statistically significant differences were identified, these differences were clinically acceptable for forensic purposes (age estimation within 1 year from chronological age). However, this potential overestimation of age might have negative implications for immigration adolescence, early adulthood and adult unidentified individual cases. In addition, the methods required for age estimation of individuals should not only be as accurate as possible, but also be safe and noninvasive to living subjects. For those reasons, third molar mineralization and development can be used to generate an estimated age range for an individual of unknown chronological age. What is more, in unidentified living/deceased individuals third molar development is useful in conjunction with age indicators in other areas of the body.[19] Differences in completion of tooth formation and maturity in development, in both arches (maxilla and mandible), have been confirmed in previous studies.[9] In addition, third molar development in the maxilla, per individual, were more advanced than in the mandible, and when we compare with the findings of Mincer *et al*.;[9] our results confirm this. What is more, it was found that when third molar root formation was complete, with closed apices and uniform width of the periodontal ligament (stage H), and there was a very high probability that the individual was at least 18 years old. Previous studies also indicate that the third molars of the maxilla in males matured earlier than those of females and those in the mandible.[19] Our findings also confirm this, for all four third molars in both arches, and combined could provide a more accurate estimation of chronological age than only using a single tooth.

Third molar tooth development stage H will most probably suggest that the person is above 18 years of age. Consequently, the stage H finding can be used for legal prosecution to determine whether an accused person of unknown age is considered an adult or minor, depending upon the laws of the country.[19,20]

The purpose of the methods used was to predict or estimate chronological age, and this has to be accurate enough for investigators to have confidence in utilizing, especially when having to determine if individuals is above or below 18 years of age, and when legal consequences are based on their decisions.

CONCLUSION

Forensic dentistry is the application of dental knowledge to those criminal and civil laws that are enforced by police agencies in a criminal justice system. Forensic dentists may also be asked to assist in the estimation of age, race, occupation, previous dental history, and socioeconomic status of unidentified human beings.

This cross-sectional study of a third molar development of 130 Western Saudi individuals was to evaluate the third molar age estimation method by Mincer *et al*. for forensic dentistry application (unknown chronological age).[9] The result of the study indicates that the third molars of individuals in the Western Saudi population studied reached the stages of development, on average, at earlier chronological ages (overestimated). This trend was found to be consistent in both males and females. Third molars of males matured earlier than those of females and in both maxilla and mandible.

In summary, age estimation of individuals of unknown age requires a reliable method that is safe and noninvasive on living subjects. Third molar tooth development can be reliably used to generate mean ages, and the estimated age range for an individual.[19]

Further studies with large populations are needed for better statistical results. The proposed data may provide a Saudi reference for maxillary and mandibular third molar examination for the purpose of forensic dentistry application.

Ethical statement

Ethics approval from the Dental Center of King Fahd Hospital, Ministry of Health, Jeddah, Saudi Arabia (H-02-J-002) and The University of Western Australia Human Research Ethics Committee was obtained prior (RA/4/1/4875) to commencing this study.

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