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Dental age estimation using radiographic assessment of third molar eruption among 10–20-year-old Ugandan population

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Abstract

Aim: This study aimed at establishing the age for third molar eruption among Ugandans aged 10–20 years. **Materials and Methods:** This was a cross-sectional study comprising 471 male and 541 female patients attending Mulago Dental Clinic. Patients' orthopantomographs were assessed for third molar eruption as described by Olze *et al*. Age was summarized using means/SD. Jaw and sex differences were assessed using Student's *t*-test. **Results:** Complete eruption (Stage D) ranged between 13 and 20 years. The mean age at complete eruption for girls and boys was 17.5–18 years and 18.2–18.6 years, respectively. Mean age was statistically significantly ($P < 0.05$) lower among girls compared to boys for all third molar teeth (#18, #28, #38, and #48). The difference in mean eruption times between girls and boys was −0.62 (95% confidence interval: 0.2–1.0, $P = 0.006$). At 18 years, 40% or 41% maxillary and 52% or 53% mandibular molars were completely erupted. There were statistically significant differences in eruption between the sexes and jaws for all teeth ($P < 0.05$). **Conclusions:** Given the fact that the percentage of erupted third molars by age 18 was found to be <50% on an average in this Ugandan population, we should reconsider the use of third molar eruption as a definitive tool for age estimation in this population.

Key words: Adolescent, age estimation, alveolar eruption, third molar, tooth eruption

Introduction

Forensic age estimation is one of the most accurate methods used to determine the chronological age of a living person involved in judicial or legal proceedings.[1] The International Interdisciplinary Study Group on Forensic Age Diagnostics recommends that age determination for individuals undergoing criminal proceedings should include a physical examination, radiographic analysis of the left hand, and a dental examination followed by an orthopantomogram (OPG) analysis.[2] The dental examinations are based on the parameters of developmental morphology observed in the process of tooth eruption.[3] These parameters are sex specific for a particular population and can predict the unknown age of an individual to a minimum extent. This estimated age is referred to as the dental age. However, differences in the tooth eruption times have been observed clinically in different races

worldwide, namely Kenyans,[4] Germans and Japanese,[3] and Croatians.[5] This implies that dental age estimation should be derived from the population in which it will be applied.

Tooth eruption as a tool for age estimation can utilize either clinical or radiographic assessment. The clinical method depends on the observation of a few stages of the tooth eruption process that occur within the oral cavity. However, the method is prone to errors or inaccuracies due to a number of factors that directly affect the tooth emergence process such as malnutrition, ankylosis, early or delayed extraction of the deciduous tooth, impaction, and overcrowding of the permanent teeth.[6] Nonetheless, due to its simplicity and low cost, the method is still being used in developing countries where eruption stages of the third molar are routinely employed in age estimation among juveniles undergoing judicial proceedings.

On the other hand, the OPG can be used to observe tooth eruption stages while the tooth is still within borne and after it has emerged into the oral cavity (3), implying the method is more reliable for forensic age estimation. In addition, among adolescents and young adults, the third molar is preferred for dental age estimation because it is the tooth still developing after 14 years of age. Despite its popularity, however, the third molar has a high variability in the age of eruption, anatomical features, and agenesis, which may have an impact on age estimation.

In Uganda, currently, one of the methods used to estimate the age of juveniles undergoing judicial proceedings is the availability of the third molar in the oral cavity. Although the third molar is being used to estimate age in this population, there are no scientifically proven standards relating the different eruption stages to specific chronological age. It has been largely assumed that the presence of the third molar in the oral cavity denotes the adulthood age of 18 years and above. This, however, may not be true in this population because research elsewhere among Kenyan population has shown third molar teeth to appear in the oral cavity as early as 13 years of age.[4] The present study set out to establish dental age estimates using radiographic third molar eruption stages among Ugandans aged 10–20 years.

Materials and Methods

Study design and setting
This was a cross-sectional study based on OPGs and oral interview of 1012 Ugandan patients aged 10–20 years attending the dental clinic of Mulago Hospital. Mulago Hospital is a national referral and teaching facility located in the capital city, Kampala, with a capacity of 1500 beds. The hospital has many specialized clinics including a dental clinic which handles patients that seek primary care or referred from lower health facilities in Uganda. Based on medical records, the clinic attends to between 1500 and 2000 patients per month, of which approximately 50% are aged 10–20 years. These patients are routinely attended to by a team of oral health workers who include oral and maxillofacial surgeons, registrars, dental surgeons, interns, and nurses.

Study population
The targeted study population was all dental patients aged 10–20 years of Ugandan descent attending the dental clinic of Mulago Hospital between January and December 2017. The patients voluntarily consented to participate in the study.

Selection of participants
The participants were consecutively selected based on the date of birth. At the time of data collection, only those participants aged ≥16 years had a national identity card and was thus used to ascertain the age of 16–20 years. On the other hand, a birth, baptism, or immunization certificate was used to ascertain those aged 10–15 years.

Data collection procedure
The background information such as sex, place of residence, and date of birth of individuals was recorded through an oral interview by a research assistant. The participants' OPGs were taken in the dental clinic of Mulago Hospital and read by two of the investigators (AKM and CML) following calibration in radiographic interpretation by an oral radiologist. The OPGs of good quality (not blurred) and showing at least one-third molar tooth on either side of the mandible without any developmental abnormality were selected. Tooth impaction was scored according to the previous classification by Winters.[7] The radiographic assessment of third molar tooth eruption was based on the following four stages of eruption as described by Olze *et al.*:[3]
- Stage A: Occlusal plane covered with alveolar bone
- Stage B: Alveolar eruption; complete resorption of alveolar bone over occlusal plane
- Stage C: Gingival eruption; penetration of gingiva by at least one dental cusp
- Stage D: Complete eruption in occlusal plane.

Reliability test
Interobserver reliability was assessed by duplicate scoring of stages of the third molar tooth eruption by the two observers (AKM and CML) in twenty patients. This yielded a Cohen's kappa coefficient of 0.96, whereas the intraobserver agreement yielded Cohen's kappa values of 0.81 and 0.96, respectively, by the two observers.

Ethical considerations
The study proposal was approved by the Research and Ethics Committee, School of Health Sciences, Makerere

University. Permission to carry out the study was obtained from the Institutional Review Board of Mulago National Referral Hospital and Uganda National Council of Science and Technology. Informed consent was obtained from the adult participants and parents/guardians of children aged 10–17 years. Assent was also obtained from the children in accordance with Helsinki declaration.

Data analysis

Data were entered using EpiData v4.2.0.0, 2005 (EpiData Association, Odense, Denmark) and analysed using STATA (version 13, STATA Corp., College Station, TX, USA). Descriptive statistics were used to summarize the data. The mean age per stage, standard deviation, minimum and maximum values, lower quartile, median, and upper quartile were determined. Student's *t*-test was used to analyze jaw and sex differences in dental age. All impacted teeth were excluded from the analysis. The probability of significance was set at 5%.

Results

Description of the study participants

The study recruited 1025 participants, but 13 participants were excluded because of poor-quality OPG images, leaving a total of 1012 Ugandan adolescents and young adults. The participants were from all the four regions of Uganda, with the majority (*n* = 539, 53.3%) from the central followed by 135 (13.3%) from the western part of the country. The age distribution of the participants was evenly distributed. Five hundred and forty-one participants (53.5%) were females [Table 1]. The total number of third molar teeth recorded was 3576, of which 1729 (48.3%) were mandibular [Table 2]. The prevalence of third molar impaction was 27.5% (*n* = 279), with 123 (44.0%) among females, and the overall missing teeth accounted for 5.3% (*n* = 193).

Dental age estimates at the various stages of third molar eruption

The prevalence of participants with all third molar teeth with complete eruption (Stage D) increased with age, from 0% in the 10 year olds to 100% in the 20 year olds [Table 2].

In general, the third molars erupted earlier in females as compared to males [Table 3]. The overall mean age difference in complete eruption between males and females ranged between 0.7 and 1.6 years, whereas the highest mean difference was 1.6 years at gingival eruption of tooth 48 [Table 3]. The mean and median ages increased with the stage of eruption of third molars from A to D in both males and females [Table 3]. The mean age at Stage D eruption of third molar teeth was significantly higher in males as compared to females (*P* < 0.05). There was no specific trend between sex differences in mean age at Stage A, B, and C eruption of all third molar teeth. The minimum and

Table 1: Frequency distribution of the study participants based on chronological age and sex (*n*=1012)

Age (years)	Females, *n* (%)	Males, *n* (%)	All*, *n* (%)
10	66 (12.2)	39 (8.3)	105 (10.4)
11	60 (11.1)	34 (7.2)	94 (9.3)
12	52 (9.6)	37 (7.8)	89 (8.8)
13	61 (11.3)	33 (7.0)	94 (9.3)
14	45 (8.3)	36 (7.6)	81 (8.0)
15	53 (9.8)	32 (6.8)	85 (8.4)
16	40 (7.4)	31 (6.6)	71 (7.0)
17	45 (8.3)	47 (10.0)	92 (9.1)
18	53 (9.8)	64 (13.6)	117 (11.6)
19	37 (6.8)	63 (13.4)	100 (9.9)
20	29 (5.4)	55 (11.7)	84 (8.3)
Total	541	471	1012

*Total number of participants by the specific age

maximum ages at complete eruption (Stage D) were 13 and 20 years, respectively, except tooth 18, which had a minimum age of 14 years [Table 3].

There was no significant difference in the mean age between the homologous pairs of third molar teeth [Table 4]. The mandibular third molar teeth significantly erupted earlier than their maxillary counterparts in all stages (*P* < 0.05), except in Stage B of teeth 28 and 18, as well as Stage C of tooth 18 (*P* > 0.05). The highest mean difference was 0.8 years, i.e., between teeth 28 and 38 at eruption Stage C [Table 4].

Discussion

In this study, we determined the mean chronological ages at which the different stages of tooth eruption were observed as described by Olze *et al*.[3] This method was preferred to the clinical eruption method because it identifies both missing and impacted teeth, and thus gives a better age estimate. It describes four distinct stages of tooth eruption that can easily be identified on the radiograph. The mean ages for the alveolar, gingival, and complete eruption stages can act as markers and provide useful information for forensic age estimation in an individual. This is one of the most commonly used techniques in studies concerning dental age estimations and has been used in diverse populations, around the world, including Germans[8] and South Africans.[9]

We found complete eruption of the third molar as early as 13 years [Table 2], which is in agreement with earlier studies among Ugandans,[10] Kenyans,[4] Nigerians,[11] and Indians.[12] By the 18th year, nearly half the sample (40%–50%) of the third molars in this study were fully erupted at Stage D [Table 2] and consequently, a higher percentage had emerged through the gingiva at Stage C. These findings are comparable to that of Tanzanian[13] adolescents. However, when compared to findings from European populations,[3]

Table 2: Frequency distribution of the participants according to age and third molars at Stage D (*n*=1012)

Age (years)	Number of participants	Tooth eruption at Stage D, *n* (%)				
		18	28	38	48	Overall
10	105	0	0	0	0	0
11	94	0	0	0	0	0
12	89	0	0	0	0	0
13	94	1 (1.1)	2 (2.2)	5 (5.8)	4 (4.6)	12 (3.4)
14	81	7 (7.7)	7 (7.7)	10 (14.7)	13 (17.5)	37 (12.4)
15	85	7 (8.7)	10 (12.6)	22 (34.9)	17 (24.3)	56 (19.2)
16	71	8 (11.6)	9 (13.4)	20 (32.8)	19 (29.7)	56 (21.4)
17	92	30 (35.3)	24 (27.9)	38 (52.0)	41 (53.2)	133 (41.4)
18	117	41 (40.2)	40 (39.6)	53 (56.9)	52 (54.2)	186 (46.9)
19	100	57 (70.4)	57 (70.4)	65 (81.2)	66 (80.5)	245 (75.8)
20	84	65 (100)	68 (100)	63 (100)	65 (100)	261 (100)
Total	1012					986

Africans have been found to exhibit early tooth eruption. Among the Germans,[8] third molars have been found to emerge much later at about the 17th year of life. Suri *et al*.[6] in a review attributed the differences in the eruption times of the third molars among populations to differences in race, ethnicity, and individual factors, among others, which may probably explain the findings in this study.

At 20 years of age, all the third molars are fully erupted in this population, indicating that the period of eruption of the third molars ranges from 13 to 20 years in the present study population [Table 2], thus making it appropriate for age estimation during late adolescence and in young adults. This finding implies that, when an individual has all the third molars at Stage D (complete eruption), then he/she would most likely be 20 years or older. Similarly, in a Nigerian population of African descent, Odusanya and Abayomi[14] reported all the third molars to have penetrated the gingiva by 19 years of age, although Ajmani *et al*.[15] found the eruption age range to lie between 15 and 21 years in the same population. However, it is difficult to compare our findings to these studies with certainty because of the differences in the definition of tooth eruption. Furthermore, it was not possible to ascertain whether all the teeth which had penetrated the gingiva were in occlusion, and the prevalence of impaction in this population was not reported. A study by Byahatti and Ingafou[16] among Libyans showed that < 33% of the third molars were fully erupted by 20 years, whereas Kruger *et al*.[17] indicated that mandibular third molars continued to erupt beyond 18 years up to 26 years of age among Europeans. This further shows that the study population is ahead of other populations.

In the present study, based on the jaws, the mean age for complete eruption of the mandibular molars was 17.5–18.2 compared to 18.0–18. Six years for maxillary molar teeth [Tables 3]. The mandibular molars erupted significantly earlier than the maxillary at all stages [Table 4]. This finding was comparable to the Kenyans[4] where the mean eruption age was 17.6–18.3 years for mandibular and 18.5–18.9 years for maxillary molars. This may probably be explained by the fact that these two populations are closely ethnically related. These findings also compare very closely with findings from the Nigerian population[15] whose mean age ranged between 18 and 18.5 years. Although these figures contrast with higher values from Africa[9] whose mean eruption age ranged between 21.7 and 22.7 years for all the third molars. Other higher values in both the maxillary and mandibular third molars were reported among Germans,[8] Japanese,[3] and Croatians.[5] The early eruption of the third molars in our study similar to other African populations compared to other races has been attributed to differences in palatal dimensions between ethnic groups. The largest palatal dimensions being observed among Africans followed by Caucasians and the smallest dimensions being reported among Asians.[18]

We observed statistically significant differences between the males and females at the eruption Stage D for all the teeth [Table 3]. In females, eruption at Stage D was 7.2 months ahead of males for teeth 18, 28 and 48, and 8.4 months for tooth 38 at stage [Table 3]. These findings were corroborated among Indians[19] where females were approximately 1.3–3.6 years ahead of males at the various stages of eruption. However, our findings were in variance to other populations like Nigerians[15] and Germans[8] where males were found to have earlier eruption of the third molars compared to females. However, among some populations like Croatians,[5] there were no significant differences observed between the sexes.

Some limitations of the present study included the assessment of Stage C which is gingival eruption was in some instances difficult to clearly identify with certainty on the radiograph bearing in mind that the gingiva is radiolucent. For cases where there was no agreement between the two investigators, the radiographs were excluded from the analysis. However caution was taken, such that when the occlusal surface of the tooth was evidently above the expected gingiva level and

Table 3: Frequency distribution of participants according to stage, mean age and standard deviation, minimum, maximum, lower quartile, and medians of eruption age for teeth 18, 28, 38, and 48, of females (n=541) and males (n=471)

Tooth	Eruption stages	Males							Females							Mean difference§	P#
		Number of cases	Mean (SD)	Minimum*	Maximum**	LQ	Median	UQ	Number of cases	Mean (SD)	Minimum*	Maximum**	LQ	Median	UQ		
18	Stage A	202	13.1 (2.6)	10	19	11	13	15	298	12.6 (2.2)	10	19	11	12	14	−0.5	0.025
	Stage B	78	15.8 (2.1)	11	19	14	16	18	78	15.2 (2.0)	10	19	14	15	17	−0.6	0.065
	Stage C	24	16.8 (1.8)	12	20	16	17	18	26	16.6 (1.6)	14	19	15	17	18	−0.2	0.607
	Stage D	119	18.6 (1.3)	14	20	18	19	20	97	18.0 (1.7)	13	20	17	18	19	−0.6	0.003
28	Stage A	207	13.1 (2.6)	10	19	11	13	15	294	12.6 (2.2)	10	19	11	12	14	−0.5	0.011
	Stage B	79	15.7 (2.0)	11	19	14	16	18	79	15.3 (2.1)	10	19	14	15	17	−0.4	0.184
	Stage C	20	17.2 (1.6)	12	19	17	17	18.5	29	16.5 (1.5)	14	19	15	17	18	−0.7	0.163
	Stage D	122	18.6 (1.4)	13	20	18	19	20	95	18.0 (1.7)	13	20	17	18	19	−0.6	0.005
38	Stage A	156	12.3 (2.3)	10	19	11	12	13	221	12.0 (1.8)	10	18	11	12	13	−0.3	0.158
	Stage B	65	15.7 (2.0)	11	19	14	16	18	88	14.8 (2.2)	10	19	13.5	15	16	−0.9	0.009
	Stage C	12	16.5 (2.1)	12	19	15	17.5	18	29	15.8 (2.1)	10	18	15	16	18	−0.7	0.371
	Stage D	151	18.2 (1.6)	13	20	17	19	20	126	17.5 (1.9)	13	20	16	18	19	−0.7	0.001
48	Stage A	152	12.3 (2.3)	10	19	11	12	13.5	228	12.0 (1.9)	10	19	10.5	12	13	−0.3	0.147
	Stage B	77	15.4 (2.1)	11	19	14	15	18	92	14.9 (2.0)	10	19	14	15	16	−0.5	0.149
	Stage C	26	16.8 (1.6)	14	19	15	17	18	28	15.2 (2.2)	10	18	13.5	15	17.5	−1.6	0.003
	Stage D	151	18.2 (1.6)	13	20	17	19	20	127	17.6 (1.9)	13	20	16	18	19	−0.6	0.003

*Minimum chronological age per eruption stage, **Maximum chronological age per eruption stage, §The mean difference of eruption age of third molars at the different stages of eruption between females and males, #The reported P value is for difference in means between males and females. SD: Standard deviation

Table 4: Frequency distribution of third molar according to mean age, standard deviation, and mean difference between the mandibular and maxillary teeth at the different stages of eruption (*n*=3576)

Eruption stage	Tooth	Number of teeth	Mean (SD)	Mean difference	t	P
A	28	501	12.8 (2.4)	0.7	4.3	0.001
	38	377	12.1 (2.0)			
B	28	158	15.5 (2.0)	0.3	1.2	0.21
	38	153	15.2 (2.2)			
C	28	49	16.8 (1.5)	0.8	1.9	0.024
	38	41	16.0 (2.1)			
D	28	217	18.4 (1.6)	0.5	2.9	0.003
	38	277	17.9 (1.8)			
A	18	500	12.8 (2.4)	0.7	4.6	0.001
	48	380	12.1 (2.0)			
B	18	156	15.5 (2.0)	0.4	1.4	0.1
	48	169	15.1 (2.1)			
C	18	50	16.7 (1.7)	0.7	1.8	0.06
	48	54	16.0 (2.1)			
D	18	216	18.4 (1.5)	0.5	2.8	0.004
	48	278	17.9 (1.8)			

SD: Standard deviation

below the occlusal plane, the teeth were classified as Stage C. Thus identifying eruption Stage C (gingival eruption) on the radiograph for purposes of age estimation can be a source of error and caution should be exercised.

Conclusions

Given the fact that the cumulative percentage of erupted third molars by age18 was found to be <50% in this Ugandan population, we should reconsider the use of third molar eruption as a definitive tool for age estimation in this population. The findings of this study form the basis for age estimation for Ugandan adolescents and young adults based on the alveolar, gingival, and complete eruption of the third molars. However, caution should be exercised when using third molar eruption, especially because of the potential errors involved.

The findings from this study can be used to formulate contemporary standards for juveniles undergoing criminal proceedings for juvenile justice.

Conflicts of interest
There are no conflicts of interest.

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