EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES

http://www.ejbps.com

ISSN 2349-8870
Volume: 6
Issue: 10
259-272
Year: 2019

AGE ESTIMATION IN IGBO ADULT NIGERIANS USING OCCLUSAL TOOTH WEAR

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Article Received on 17/07/2019 **Article Revised on 06/08/2019** **Article Accepted on 27/08/2019**

ABSTRACT

Tooth wear (TW) is said to correlate with chronological age and the durability of the tooth as well as its ability to withstand pressure and death related changes made it the choice for the study. Igbo adults (198 between the ages of 21-60 years) resident in the south-east were sampled. Those who gave their consent and reached the benchmark for selection were therefore studied. Tooth wear patterns were obtained using alginate-based impression material, which was cast using a grade IV dental stone. From the casts, occlusal tooth wear was scored 0 – 10 according to the pattern and degree of wear using the adjusted Kim's scoring system. The teeth were numbered 14, 15, 16, 17, 24, 25, 26, 27, 34, 35, 36, 37, 44, 45, 46 and 47 following FDI nomenclature. Results were analyzed using Statistical Package for the Social Sciences (SPSS IBM®, version 25.0, Armonk, New York, USA) and Minitab version 18.0 (Minitab® Inc. State College, Pennsylvania). Mean values were presented as Mean ± SD, Mann Whitney U test was used to establish sex differences, while stepwise multivariate and univariate regression was used to estimate age from tooth wear score (TWS). Females had higher tooth wear scores compared to males. Except for tooth number 14 (t=-3.08; p= 0.00), 24 (t=-3.03; p= 0.00) & 44 (t=-2.68; p= 0.01), observed sex differences were not statistically significant. A strong positive correlation was observed between TWS and age; [r = 0.84 (male), r = 0.85 (female)]. TW was able to predict age with 71% (male); 72% (female) accuracy. A higher percentage (63.5%) of subjects between the age of 31 – 40 had estimated age ±3 years of their actual age, while those between 41 – 50 had the least prediction accuracy (29.4%). The study will be helpful in forensic investigations and archaeological studies, especially when other body parts are not available.

KEYWORDS: Occlusal, Tooth, Wear, Age, Estimation.

1 INTRODUCTION

Life and life events revolve around age. Currently age is a prerequisite for employment, admission into schools, military and paramilitary bodies. In clinical practice, age is important in disease diagnosis as well as in treatment.[1] Age is often falsified, disputed, under or over estimated. Considering the role of age in the day to day life of an individual, a number of Authors have attempted to estimate age, especially to solve crime and determine the course of justice.[2], [3]

Age is primarily required when it comes to personal identification (an important aspect of forensic anatomy, clinical practice, law court and dentistry) and search for missing individuals, often providing useful information in search and identification of missing persons.[4]

Other factors such as sex, stature and race are also helpful in forensic procedure (such as personal identification), but age reduces the extent of assumptions.[5], [6] Hence estimating the age of unidentified body facilitates the procedure for gathering ante mortem data by narrowing the age interval to be considered during search operations. It also has immense social benefits especially for individuals who have no birth record and are unaware of their age.

Depending on post mortem conditions (biological, chemical or mechanical) and how long death may have occurred, other body parts may undergo gross disintegration, but not the teeth which is outwardly re-enforced by enamel; the hardest substance to exist in the human body and the most durable as well as resilient part of the human skeleton.[7],[8]

The tooth is sometimes the only body part available for study in human remains long after bones and other body tissues have disintegrated.[9],[10],[4],[11],[12],[13],[14] Surprisingly, the teeth can withstand temperatures in excess of 1600°C, which implies that even in the event of fire disaster, where victims were burnt beyond repair and bony structures denatured by fire, the teeth will remain intact, without any gross damage. [15] As a result of these factors (resilience, slow disintegration etc.), the teeth are always available post mortem [16] for age estimation,[17], [14], [18], [19] victim identification and other related forensic inquests.

Generally, the teeth undergo a lot of age-related alterations. However, most of these changes may be considered pathologic, but attrition (wear) which progressively increases with advancing age, is considered physiologic.

Active use of the teeth begins from the sixth (6th) year of life, when the functional-age of the teeth begins.[20] Wear and tear (abrasion / abfraction or attrition) occur due to occlusion which occurs during biting, tearing, chewing, or any activity capable of forcing the teeth in both jaws to come together (occlude). The extent of these wear and tear is said to correlate with chronological age (how long one has lived), even in lower animals: baboons,[21] gazelles,[22] wild Eurasian badgers,[23] deer[24] as well as other primate species.[25], [26]

This study developed a model for age estimation from tooth wear score using the modified Kim's scoring system in Igbo adult in Nigeria.

2. MATERIALS AND METHODS

It was a cross-sectional descriptive study designed to randomly select 198 [115 (Males); 83 (Females)] Igbo adults between the ages of 21 to 60 years. The study was carried out in selected cities in South-Eastern Nigeria (Owerri, Onitsha, Aba, Nnewi, Awka, Enugu, Abakaliki etc.). Subjects who met the inclusion criteria were included in the study. Ethical approval was obtained from the University of Port Harcourt Research Ethics Committee, with the reference number UPH/CEREMAD/REC/04.

Selection Criteria

Inclusion Criteria

The following criteria was considered:

1. Individuals who are of Igbo extraction by both parents up to the 3rd generation.
2. Individuals with class I dental occlusion, without overcrowding and tooth agenesis.

Exclusion Criteria

1. Individuals with abnormal dental conditions; such as malocclusions and impaction.
2. Those with anomalies of the palate and cleft lips (such as cleft palate and lips).

2.1 Procedure for data collection

Data collection (dental cast models) was carried out following.[27]

3.5.1 Subject Selection and Education

Subjects who gave their consent and met the inclusion criteria were selected for the study. Consent was sought through an informed consent form given to the subjects. The procedure as well as the benefits of the study verbally explained to them. The following was explained to the subjects.

Subjects biodata, such as State of origin, age, sex, feeding habit (such as carbonated drink consumption rate and vegetarianism) and reference code was collected using Open Data Kit (ODK); a software solution for paper questionnaire used for data collection by field scientists.

3.5.2 Taking tooth impression using alginate

This was done in the following steps:

1) A type II chromatic alginate (Sodium alginate and calcium sulphate) impression material of normal setting (manufactured by Asmy Asade Nig. Ltd) was used to make an imprint of the teeth together with the adjacent structures.
2) About 2 scoops of distilled water was measured into a plastic mixing bowl, while 2 scoops of alginate were measured into a cup and added to the water.
3) A wide bladed spatula was used to rapidly mix/swipe the alginate mass against the sides of the bowl to avoid entrapment of air in the mix. This was done at room temperature (23°C) for about 30 – 45 secs until it turns purple red.

3.5.3 Selecting Impression Tray and Loading Alginate

Perforated stock impression tray was used to load the alginate paste. Perforated spaces on the tray ensures that the solidified alginate is locked and held the tight to the tray. This prevents lifting or distortion of the alginate impressions during removal. Two types of tray are were utilized in the study; one for the maxillary dental arch and the other for the mandibular. The maxillary tray is closed like a trowel, while for the mandibular, space is created for the tongue. Impression tray do come in different sizes, hence the appropriate size for an individual was selected in making their dental impressions.

3.5.4 Preparing the Mouth for Impression

The mouth was rinsed with water to moisten the teeth and eliminate debris and food particles which may fill up the occlusal surfaces. When the mouth (teeth) is dry, alginate radicals may react with the hydroxyapatite crystals of the enamel forming strong bonds. Alginate tears upon removal if this happens.[28]

3.5.5 Loading the Impression Tray and making Impressions

a. The subject was made to sit on a comfortable chair.
b. The mixture was first rubbed on the occlusal surfaces to fill up the grooves.
c. The mouth was opened and the tray loaded with alginate (to about 3mm thick from the tray) was placed in position and the mouth closed.

d. The subjects were asked not to apply any pressure, as this would cause the impression to set under strain, leading to distortion or inaccurate cast upon removal. Loading alginate into the tray and taking impression was done within 45 secs after mixing, beyond which setting begins. The chromatic alginate was pink at this stage.

3.5.6 Removal and Inspection of Impression

a. After about 1 – 2 mins, the impression was considered set (when it turns white) and removed using a firm quick-snap. The index fingers were placed on the buccal sulci breaking the seal between the tissues and the impression tray. The thumb held the handle of the tray, with the other fingers supporting the tray.
b. After removal, defects, presence of saliva or blood cloth was checked under good lighting condition. And if any, the impression was rinsed in running tap water (and dried immediately with a damp napkin to avoid imbibition), while thick serous saliva and blood cloths were gently removed using a wet camel's hair brush.

3.5.7 Casting and de-casting

a. A type IV grade dental stone ISO 13485-2016 (manufactured by Mr. Dental Supplies Limited, England, United Kingdom) was mixed with water to form a pouty and gently poured into the tray with the impressions facing downwards.
b. The cast was allowed to set and removed (de-casted) thereafter to avoid a perforated ("moth-eaten") appearance.
c. The casts were coded according to the reference code given to the individuals in their ODK forms. This was done to avoid mix-ups.

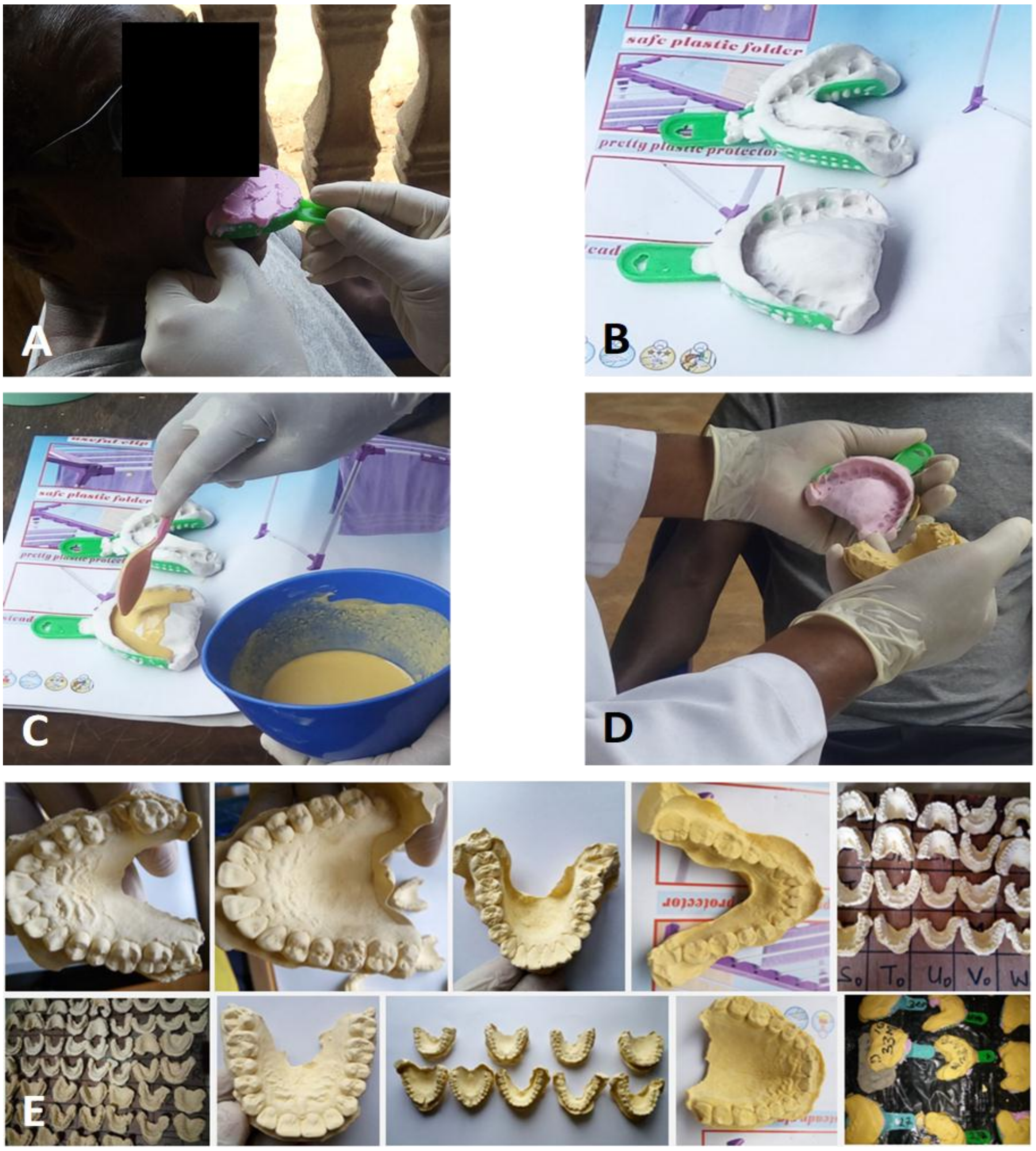

Figure 1A-B; taking impression, C; tray showing tooth impression, D-E; casting and F; de-casting.

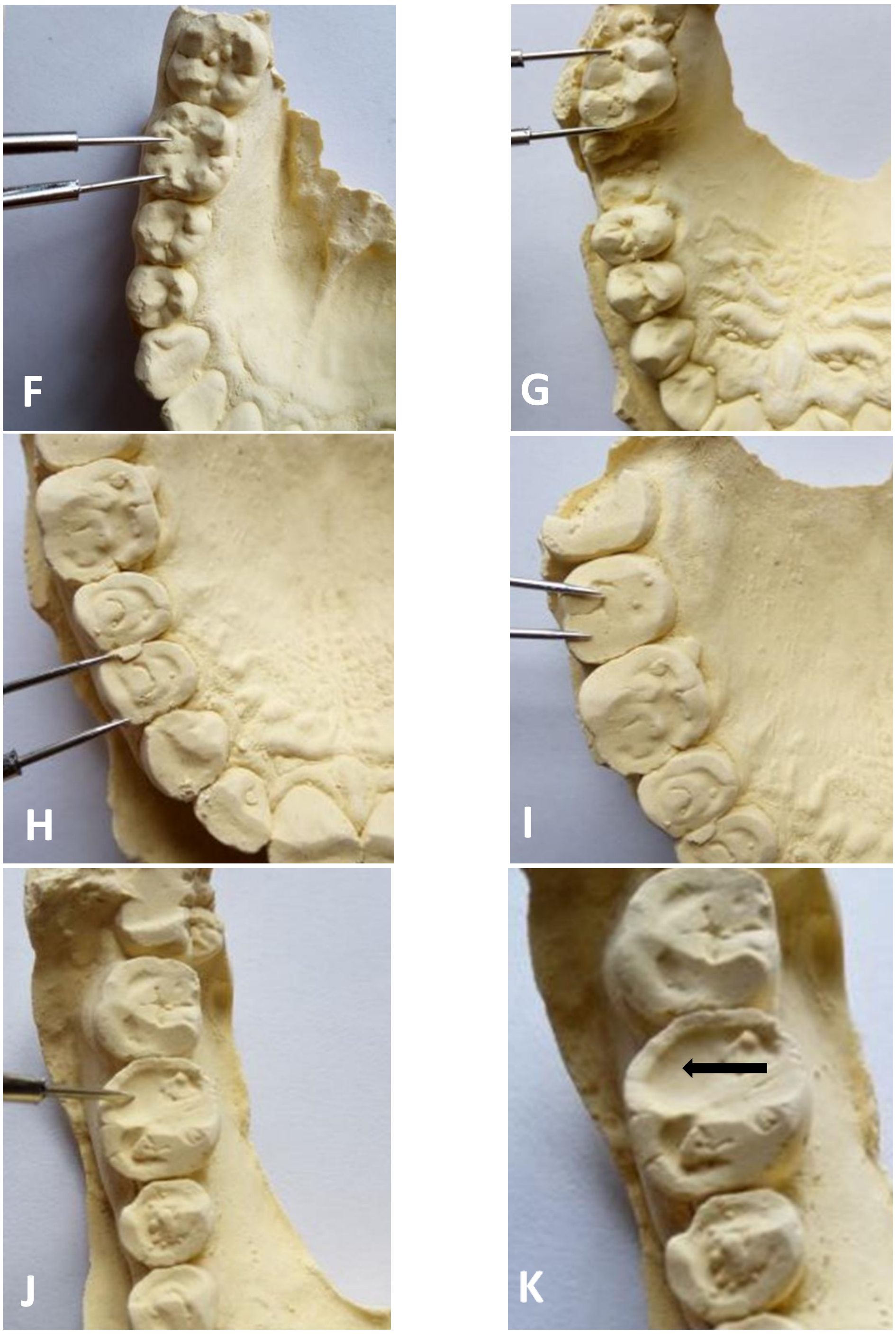

Figure 1F; Point-like wear facet less than 1mm in diameter, G; Linear-like wear less than 1mm in width, H; Surface-like wear greater than 1mm in diameter, I; Band-like wear greater than 1mm in width and J-K; Concavity of the dentine.

3.5.8 Scoring Tooth Wear Pattern from the Cast

Full maxillary and mandibular impressions were obtained, from the dental cast model prepared using alginate impression material.

All the posterior sixteen (16) out of the (32) permanent teeth were examined for tooth wear with the naked eye under good illumination, using a magnifying glass (manufactured by Ningbo-Hongbo Optical Instrument Co., Ltd. Zhejiang, China ISO 9001, ISO 9000). Tooth wear pattern from canine to canine were not considered because of their wide angular variations from individual to individual. The third (3rd) molar (wisdom tooth) which is not present in every individual and may sometimes be impacted was also not considered.

The tooth scored were numbered following the world-wide accepted *Federation dentaire internationale* (FDI) nomenclature. Pattern, number and the amount of TW (degree of dentin exposure) was observed, measured and assigned scores (0 – 10) based on the scoring system developed by Kim *et al*[29] and modified by Lu *et al*.[30] (Table 1). Three (3) trained research assistant were employed who also observed and independently assigned relevant scores. Tooth wear was evaluated by two different criteria; pattern and the extent of dentin exposure.

Table 1: Modified Kim's scoring system.

SCORE	PREMOLAR	MOLAR
0	No visible wear	No visible wear
1	1P / lL	1P / 1L / 2P / 2L
2	2P / 2L / 1S / lB	3P / 3L / 4P / 4L / 1S / 1B / 2S / 2B
3	2S / 2B	3S / 3B / 4S / 4B
4	Wear on more than 2/3 occlusal surface	-
5	1Pc / lLc	1Pc / lLc / 2Pc / 2Lc
6	2Pc / 2Lc / lSc / lBc	3Pc / 3Lc / 4Pc / 4Lc / lSc / lBc / 2Sc / 2Bc
7	2Sc / 2Bc	3Sc / 3Bc / 4Sc / 4Bc
8	Concavity on more than 2/3 occlusal surface	-
9	Filling, ∗caries, ∗crown (all teeth)	
10	Missing, stump of tooth, pontic, denture (all teeth)	

**If the extent of filling materials or caries does not exceed 1/3 of the occlusal surface so that the degree of occlusal tooth wear can be determined, the appropriate score should be given.*
***P**, point-like wear facet less than c. 1mm in diameter;*
***L**, linear wear facet less than c. < 1mm in width;*
***S**, surface-like wear facet greater than c. 1mm in diameter;*
***B**, band-like wear facet greater than c. 1mm in width or wear facet involving more than two surface-like wear facets.*
'/' means 'or.'
'c'(concavity), the wear of dentin.
Where there are several degrees of tooth wear, the highest value is taken.

3.6 Method of Data Analysis
Data was analyzed using Statistical Package for the Social Sciences (IBM® SPSS version 25.0, SPSS Inc., Chicago, IL, USA), Minitab version 18.0 (Minitab® Inc. State College, Pennsylvania) and Microsoft Excel 2019 Statistical Tool pack. The criterion level for significance was set at 95%; hence $p < 0.05$ was considered significant. Tooth wear scores were expressed as Mean$\pm$SD, independent sample t-test as well as paired t-test was used to establish side differences, the predictability of age from tooth wear score was determined using correlation and stepwise multivariate and univariate regression.

3.7 Reliability of the Modified Kim's Scoring System
The reliability of Kim's assessment system as modified by Lu *et al*[30], was evaluated using Fleiss' Kappa statistics; which determines the inter-rater reliability between the examiners. A 95% significant average concordance (P<0.001) for all tooth wear scores and 95.0% (CI of 86.60-97.02; P<0.001) overall attribute agreement between the evaluators was observed.

3. RESULTS AND DISCUSSION

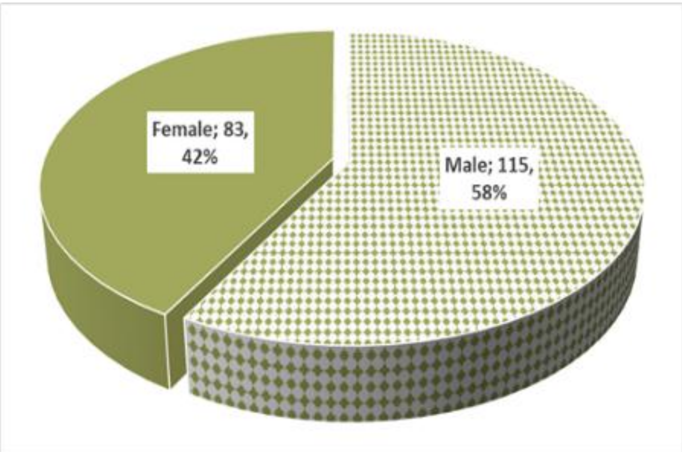

Figure 1: Distribution of the subjects according to sex.

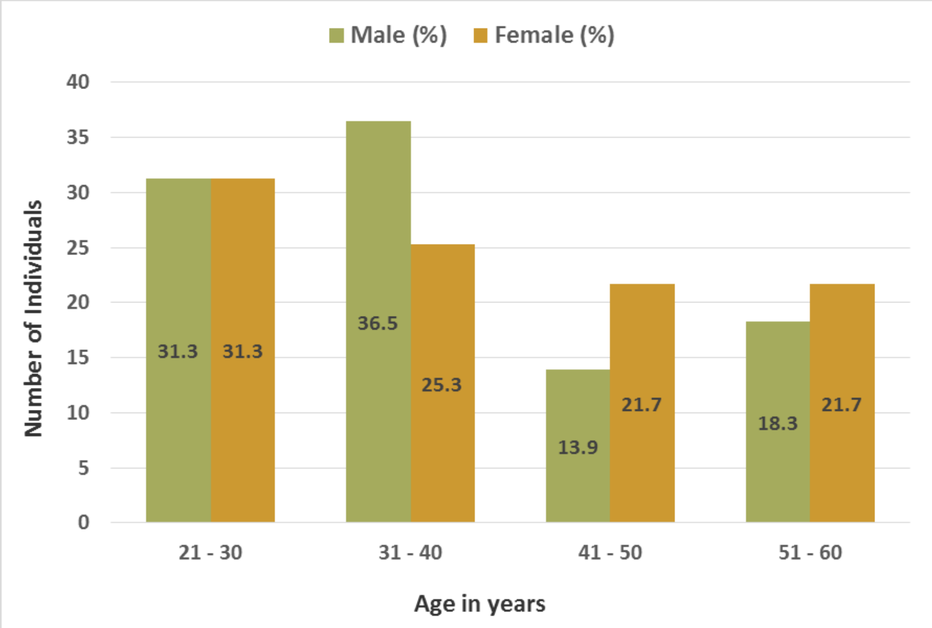

Figure 2: Distribution of the subjects according age.

Table 2: Descriptive statistics of occlusal tooth wear score among the subjects.

Tooth Wear Score	MALE [N = 115]				FEMALE [N = 83]				ALL [N = 198]			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
14	2.37	0.95	1	4	2.80	0.95	1	5	2.55	0.97	1	5
15	3.43	1.56	1	8	3.63	1.76	1	8	3.52	1.65	1	8
16	3.59	1.75	1	10	384	1.66	2	8	3.70	1.71	1	10
17	4.46	2.10	1	8	4.78	2.04	2	8	4.60	2.07	1	8
24	2.43	0.92	1	4	2.83	0.89	1	4	2.60	0.93	1	4
25	2.81	1.05	1	8	2.93	1.18	1	8	2.86	1.10	1	8
26	3.82	1.73	1	8	3.93	1.61	1	8	3.86	1.68	1	8
27	3.82	1.70	1	8	3.88	1.64	1	8	3.84	1.67	1	8
34	2.86	0.91	1	5	2.94	0.95	1	5	2.89	0.93	1	5
35	3.60	1.54	2	8	3.72	1.55	1	8	3.65	1.54	1	8
36	3.64	1.64	1	8	3.75	1.73	1	8	3.69	1.67	1	8
37	4.20	2.24	1	8	4.13	1.98	1	8	4.17	2.13	1	8
44	2.33	0.86	1	4	2.67	0.94	1	5	2.47	0.91	1	5
45	3.29	1.27	1	8	3.29	1.71	1	8	3.29	1.46	1	8
46	3.80	1.82	1	8	3.81	1.80	1	8	3.80	1.81	1	8
47	4.09	2.32	1	8	4.01	2.00	1	8	4.06	2.18	1	8

***N** = Amount, **SD** = Standard Deviation*

Table 3: Mann Whitney U test comparing the occlusal tooth wear score in male and female subjects.

Tooth Number	Sex	N	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	p-value
14	Male	115	90.23	3706.50	10376.50	-2.81	**0.00***
	Female	83	112.34				
15	Male	115	96.68	4448.50	11118.50	-0.85	0.40
	Female	83	103.40				
16	Male	115	94.99	4253.50	10923.50	-1.36	0.17
	Female	83	105.75				
17	Male	115	96.36	4411.50	11081.50	-0.94	0.35
	Female	83	103.85				
24	Male	115	90.00	3679.50	10349.50	-2.93	**0.00***
	Female	83	112.67				
25	Male	115	98.30	4634.50	11304.50	-0.37	0.71
	Female	83	101.16				

26	Male	115	96.14	4386.00	11056.00	-1.01	0.31
	Female	83	104.16				
27	Male	115	97.58	4552.00	11222.00	-0.58	0.56
	Female	83	102.16				
34	Male	115	97.94	4593.00	11263.00	-0.48	0.63
	Female	83	101.66				
35	Male	115	96.03	4373.50	11043.50	-1.05	0.29
	Female	83	104.31				
36	Male	115	98.63	4672.50	11342.50	-0.26	0.79
	Female	83	100.70				
37	Male	115	99.18	4736.00	11406.00	-0.09	0.93
	Female	83	99.94				
44	Male	115	91.65	3869.50	10539.50	-2.40	**0.02***
	Female	83	110.38				
45	Male	115	103.55	4306.50	7792.50	-1.23	0.22
	Female	83	93.89				
46	Male	115	99.33	4752.50	11422.50	-0.05	0.96
	Female	83	99.74				
47	Male	115	98.97	4711.50	11381.50	-0.16	0.88
	Female	83	100.23				

** = Significant at p < 0.05*

Table 4a: Descriptive statistics of mean tooth wear score of each tooth for different age groups and test of comparison using analysis of variance (ANOVA).

Tooth FDI Number	Age in years																	
	21 - 30 [N = 62]				31 - 40 [N = 63]				41 - 50 [N = 34]				51 - 60 [N = 39]				ANOVA (*df* = 3)	
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	*F*-value	*p*-value
14	2.31	0.90	1	4	2.21	0.95	1	4	3.03	0.87	1	5	3.08	0.81	1	4	12.40	0.00*
15	2.94	0.85	1	4	2.84	0.85	1	6	3.41	1.16	1	8	5.62	2.18	2	8	45.74	0.00*
16	3.11	1.40	2	10	3.02	1.05	1	8	3.74	1.50	2	8	5.69	1.69	4	8	35.75	0.00*
17	3.13	1.49	1	8	3.94	1.15	2	8	5.82	1.88	2	8	6.92	1.55	3	8	64.49	0.00*
24	2.37	1.00	1	4	2.59	0.87	1	4	2.74	0.79	1	4	2.87	0.95	1	4	2.69	0.06
25	2.42	0.76	1	4	2.84	0.75	1	4	3.00	0.70	2	4	3.46	1.83	2	8	8.14	0.00*
26	3.15	1.23	1	8	3.37	1.07	1	8	4.18	1.78	2	8	5.54	1.83	2	8	26.26	0.00*
27	3.06	1.05	1	8	3.35	1.05	1	8	4.18	1.78	2	8	5.59	1.89	2	8	30.18	0.00*
34	2.69	0.95	1	5	2.81	0.90	1	5	3.09	0.90	1	5	3.18	0.88	2	5	2.97	0.03*
35	3.11	1.17	2	8	3.22	1.17	1	8	4.09	1.64	2	8	4.82	1.78	2	8	15.31	0.00*
36	2.97	1.06	1	8	3.11	1.05	1	8	4.00	1.71	2	8	5.49	1.90	2	8	31.94	0.00*
37	2.97	1.38	1	8	3.94	1.69	2	8	3.71	1.82	2	8	6.87	1.69	2	8	48.72	0.00*
44	2.11	0.70	1	4	2.30	0.96	1	4	2.74	0.79	1	4	3.10	0.82	2	5	13.39	0.00*
45	2.69	0.78	1	4	2.78	1.01	1	8	3.35	1.10	1	8	5.00	1.85	3	8	36.61	0.00*
46	2.95	1.06	1	8	3.13	1.08	1	8	4.12	1.77	2	8	5.97	1.91	2	8	43.91	0.00*
47	2.77	1.59	1	8	3.83	1.63	2	8	3.71	1.82	2	8	6.77	1.74	2	8	47.14	0.00*

** = Significant at p < 0.05, **N** = Amount, **SD** = Standard Deviation, **df** = degree of freedom, **Min** = Minimum, **Max** = Maximum*

Table 4b: Tukey's post hoc test comparing the mean tooth wear score of each tooth for different age groups.

Age in years [I]	Age in years [J]	*Tooth FDI Number (p-value)*													
		14	15	16	17	25	26	27	34	35	36	37	44	45	46	47
21 - 30	31 - 40	0.92	0.98	0.98	0.01*	0.11	0.82	0.66	0.89	0.97	0.94	0.01*	0.58	0.98	0.90	0.00*
21 - 30	41 - 50	0.00*	0.30	0.15	0.00*	0.05	0.00*	0.00*	0.18	0.01*	0.00*	0.15	0.00*	0.05	0.00*	0.05
21 - 30	51 - 60	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.04*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
31 - 40	41 - 50	0.00*	0.15	0.07	0.00*	0.89	0.04*	0.03*	0.48	0.02*	0.01*	0.91	0.07	0.10	0.01*	0.99
31 - 40	51 - 60	0.00*	0.00*	0.00*	0.00*	0.02*	0.00*	0.00*	0.19	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
41 - 50	51 - 60	1.00	0.00*	0.00*	0.01*	0.24	0.00*	0.00*	0.97	0.12	0.00*	0.00*	0.24	0.00*	0.00*	0.00*

** = Significant at p < 0.05*

Table 5: Correlation between age and tooth wear score for each tooth.

FDI Tooth Number	Age in years for males [N = 115]			Age in years for females [N = 83]		
	r	R^2	*p*-value	*r*	R^2	*p*-value
14	0.37	0.14	0.00**	0.30	0.09	0.01**
15	0.58	0.34	0.00**	0.51	0.26	0.00**
16	0.53	0.28	0.00**	0.56	0.31	0.00**
17	0.67	0.45	0.00**	0.79	0.62	0.00**
24	0.21	0.04	0.02*	0.13	0.02	0.24
25	0.30	0.09	0.00**	0.36	0.13	0.00**
26	0.50	0.25	0.00**	0.59	0.35	0.00**
27	0.52	0.27	0.00**	0.61	0.37	0.00**
34	0.38	0.14	0.00**	0.09	0.01	0.41
35	0.41	0.17	0.00**	0.48	0.23	0.00**
36	0.50	0.25	0.00**	0.64	0.41	0.00**
37	0.61	0.37	0.00**	0.61	0.37	0.00**
44	0.35	0.12	0.00**	0.50	0.25	0.00**
45	0.51	0.26	0.00**	0.58	0.34	0.00**
46	0.58	0.34	0.00**	0.67	0.45	0.00**
47	0.59	0.35	0.00**	0.67	0.45	0.00**

** = correlation was significant at $p < 0.01$, * = correlation was significant at $p < 0.05$

Table 6a: Analysis of variance for fit regression model, percentage contribution and variables predictability of age and tooth wear score among male subjects.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	**6**	11575.7	71.17%	11575.7	1929.29	44.43	**0.00***
15	1	5406.3	33.24%	280.7	280.74	6.47	**0.01***
17	1	3571.9	21.96%	1488.1	1488.11	34.27	**0.00***
34	1	300.7	1.85%	218.2	218.20	5.03	**0.03***
37	1	1235.6	7.60%	295.2	295.21	6.80	**0.01***
45	1	813.1	5.00%	568	568.01	13.08	**0.00***
46	1	248.1	1.53%	248.1	248.09	5.71	**0.02***
Error	**108**	4689.3	28.83%	4689.3	43.42		
Lack-of-Fit	103	4660.6	28.65%	4660.6	45.25	7.89	**0.01***
Pure Error	5	28.7	0.18%	28.7	5.73		
Total	**114**	**16265**	**100.00%**				

Note: *Criterion for remaining in the model, α ≤0.05; * = Model is a good fit at P<0.05 (3 out of the 16 variables were significantly involved in the prediction),* ***Seq*** *= Sequential,* ***SS*** *= Sums of squares,* ***Adj*** *= Adjusted,* ***DF*** *= Degrees of freedom,* **n/a** = not available

Table 6b: Analysis of variance for fit regression model, percentage contribution and variables predictability of age and tooth wear score among female subjects.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	3	7952.7	72.03%	7952.7	2650.91	67.81	**0.00***
16	1	3447.8	31.23%	165.6	165.57	4.24	**0.04***
17	1	4076.3	36.92%	2528.4	2528.39	64.67	**0.00***
47	1	428.6	3.88%	428.6	428.60	10.96	**0.00***
Error	79	3088.4	27.97%	3088.4	39.09		
Lack-of-Fit	78	3087.9	27.97%	3087.9	39.59	79.18	0.09
Pure Error	1	0.5	0.00%	0.5	0.50		
Total	**82**	**11041.2**	**100.00%**				

Note: *Criterion for remaining in the model, α ≤0.05; * = Model is a good fit at P<0.05 (3 out of the 16 variables were significantly involved in the prediction),* ***Seq*** *= Sequential,* ***SS*** *= Sums of squares,* ***Adj*** *= Adjusted,* ***DF*** *= Degrees of freedom*

Table 7a: Regression analysis of age and tooth wear score among male subjects.

Term	Coef	SE Coef	VIF	95% CI	T-Value	P-Value
Constant	3.43	2.57		(-1.66, 8.52)	1.34	0.18
15	1.25	0.49	1.54	(0.275, 2.218)	2.54	**0.01***
17	2.17	0.37	1.58	(1.433, 2.899)	5.85	**0.00***
34	1.65	0.74	1.17	(0.191, 3.109)	2.24	**0.03***
37	0.93	0.36	1.69	(0.224, 1.641)	2.61	**0.01***
45	2.06	0.57	1.37	(0.932, 3.192)	3.62	**0.00***
46	1.07	0.45	1.76	(0.183, 1.964)	2.39	**0.02***

Coef *= Coefficient,* ***S.E*** *= Standard error;* ***VIF*** *= Variance Inflation Factors*

Table 7b: Regression analysis of age and tooth wear score among female subjects.

Term	Coef	SE Coef	VIF	95% CI	T-Value	P-Value
Constant	13.37	2.02		(9.34, 17.40)	6.60	**0.00***
16	1.066	0.52	1.54	(0.035, 2.097)	2.06	**0.04***
17	3.302	0.41	1.48	(2.485, 4.120)	8.04	**0.00***
47	1.52	0.46	1.77	(0.606, 2.434)	3.31	**0.00***

Coef *= Coefficient,* ***S.E*** *= Standard error;* ***VIF*** *= Variance Inflation Factors,* ***CI*** *= Confidence Interval*

Table 8a: Model Summary for the regression analysis and variables predictability of age and tooth wear score among male subjects.

Model	R	R-sq	R-sq (adj)	R-sq (pred)	S.E (est)
Predictors	0.84	0.71	0.7	0.67	6.59

R *= Karl Pearson correlation,* ***R-sq*** *= R-squared,* ***S.E*** *= Standard Error of the estimate,* ***adj*** *= adjusted,* ***pred*** *= predicted,* ***Predictors*** *= 15, 17, 34, 37,45 and 46*

Regression equation (Male): All tooth wear score that significantly predicted age

Age in years = C + Coef (S_n)………+Coef (S_n), where C = Constant, Coef = Coefficient, S = Score, n = FDI tooth number.

Age (years) = 3.43 + 1.246 (S_{15}) + 2.166 (S_{17}) + 1.650 (S_{34}) + 0.932 (S_{37}) + 2.062 (S_{45})+ 1.074 (S_{46}).

Table 8b: Model Summary for the regression analysis and variables predictability of age and tooth wear score among female subjects.

Model	R	R-sq	R-sq (adj)	R-sq(pred)	S.E (est)
Predictors	0.85	0.72	0.71	0.68	6.25

R *= Karl Pearson correlation,* ***R-sq*** *= R-squared,* ***S.E*** *= Standard Error of the estimate,* ***est*** *= estimate,* ***adj*** *= adjusted,* ***pred*** *= predicted,* ***Predictors*** *= 16, 17 and 47*

Regression equation (Female): All tooth wear score that significantly predicted age

Age (years) = 13.37 + 1.066 (S_{16}) + 3.302 (S_{17}) + 1.520 (S_{47})

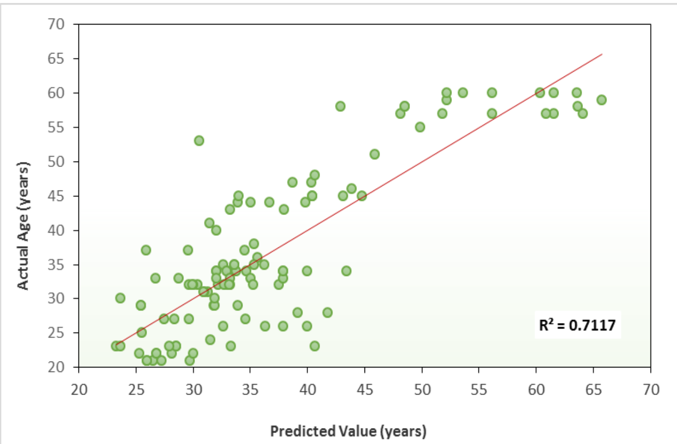

Figure 3a: Scatterplot of predicted age versus actual age for male subjects.

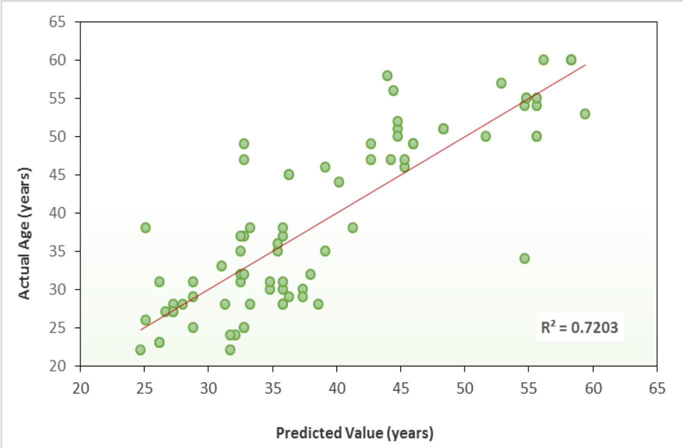

Figure 3b: Scatterplot of predicted age versus actual age for female subjects.

Table 9: Summary table for age predictability using the corresponding regression equations.

Sex	Predicted age that lies within the actual age range (in years)			
	±3years	±5years	±10years	Above 10
M (n = 155)	45 (39.1)	21 (18.3)	37 (32.2)	12 (10.4)
F (n = 83)	36 (43.4)	17 (20.5)	23 (27.7)	7 (8.4)
Both (M & F)	81 (40.9)	38 (19.2)	60 (30.3)	19 (9.6)

M *= Male,* ***F*** *= Female,* ***n*** *= amount*

Table 10: Summary table for age predictability using the corresponding regression equations.

Age in years	±3 years	±5 years	±10 years	Above 10
21 - 30	17 (27.4)	14 (22.6)	23 (37.1)	8 (12.9)
31 - 40	40 (63.5)	13 (20.6)	7 (11.1)	3 (4.8)
41 - 50	10 (29.4)	5 (14.7)	15 (44.1)	4 (11.8)
51 - 60	14 (35.9)	6 (15.4)	15 (38.5)	4 (10.3)

Results were presented in Figure 1 – 3b as well as Table 2 – 10. The distribution of the subjects according to sex and age were presented in Figure 1 and 2 respectively, while scatterplot of predicted and actual age was presented in Figure 3a and b. Descriptive statistics of occlusal tooth wear score was presented in Table 2. Mann Whitney U test was presented in Table 3. In Table 4a, distribution of the subjects according to age and analysis of variance was presented, while Turkey's post hoc test was presented in Table 4b. Correction analysis was presented in Table 5 – 8b. A summary table for age predictability using the corresponding regression equations were presented in Table 9 – 10.

As presented in Table 2, mean tooth wear score (**TWS**) for all 16 teeth were higher in females: Tooth number (**TN**) 14 (M = 2.37±0.95; F = 2.80±0.95), 15 (M = 3.43±1.56; F = 3.63±1.76), 16 (M = 3.59±1.75; F = 3.84±1.66), 17 (M = 4.46±2.10; F = 4.78±2.04), 24 (M = 2.43±0.92; F = 2.83±0.89), 25 (M = 2.81±1.05; F = 2.93±1.18), 26 (M = 3.82±1.73; F = 3.93±1.61), 27 (M = 3.82±1.70; F = 3.88±1.64), 34 (2.86±0.91; F = 2.94±0.95), 35 (M = 3.60±1.54; F = 3.72±1.55), 44 (M = 2.33±0.86; F = 2.67±0.94), 45 (M = 3.29±1.27; F = 3.29±1.71), 46 (M = 3.80±1.82; F = 3.81±1.80). While, TN 36 (M = 3.64±1.64; F = 3.75±1.73), 37 (M = 4.20±2.24; F = 4.13±1.98) and 47 (M = 4.09±2.32; F = 4.01±2.00) had higher mean TWS in male subjects. TN 17 had the highest mean wear score (M = 4.46; F = 4.78) in both sexes, while TN 44 had the least score (M = 2.33; F = 2.67).

Berbesque *et al*[31] and Lu *et al*[30] made similar findings. However, Seligman *et al*[32], Spijker *et al*[33] and Lahari *et al*[34] observed the contrary, with males having higher attrition scores.

In Table 3, mean TWS for both sexes were compared. Except TN 14 (z = -2.81, P = 0.00), 24 (z = -2.93, P = 0.00) and 44 (z = -2.40, P = 0.02), there was no significant difference between male and female subjects in TWS.

Subjects were further divided into 4 age groups (21 – 30, 31 – 40, 41 – 50 and 51 – 60) as presented in Table 4a. All the 16 teeth investigated, had statistically significant differences in TWS across the groups, except TN 24 ($F_{[df=3]}$ = 2.69, P = 0.06). Turkey's post hoc test presented in Table 4b showed where the differences lie. Older individuals presented significantly higher TWS compared to the younger ones (51 – 60 and 21 – 30). Similar findings were made by Kim *et al*[29], Wetselaar *et* *al*[35], Lu *et al*[30] and Uzuner *et al*.[36] According to Anatoly *et al*[37], enamel undergoes age-associated changes in structural integrity characterized by reduced mineralization, which increases its fragility. Also, dental and oral hygiene may also decrease with age,[38] resulting to an increase in periodontal disease and caries.[39],[37] However, functional age is directly proportional to tooth wear, suggesting that older individual will hypothetically have more dental wear and tear when compared to the younger ones.

Correlation and stepwise multivariate regression analysis were carried out to estimate age from tooth wear. Every individual tooth did not contribute to age estimation. TN 17 had the highest correlation in both subjects, while 24 (r = 0.21) and 34 (r = 0.09) were the least in male and female subjects respectively (Table 5). Only TN 15, 17 (33.24%), 37 (7.60%), 45 (5.00%), 34 (1.85%) and 46 (1.53%) contribution to the regression model in males (Table 6a), while 17 (36.92%), 16 (31.23%) and 47 (3.88%) contributed in females (Table 6b).

A very strong positive correlation (R = 0.84) was observed between age and TWS in males (Table 7a). Age can be estimated from the linear expression; Age = 3.43 + 1.246 (S_{15}) + 2.166 (S_{17}) + 1.650 (S_{34}) + 0.932 (S_{37}) + 2.062 (S_{45}) + 1.074 (S_{46}), which can estimate age with 71% accuracy. In females, a very strong positive correlation (R = 0.85) was also observed between age and TWS (Table 7b). Age can be estimated from the linear expression; Age = 13.37 + 1.066 (S_{16}) + 3.302 (S_{17}) + 1.520 (S_{47}), with a prediction accuracy of 72%.

A summary table for age predictability using the derived multivariate regression equation was presented in Table 9 and 10.

Predicted age was compared to actual age range to determine the number of individuals with estimated age within $\pm$3 years, $\pm$5 years, $\pm$10 years and, or above 10 years of their actual age. For males; estimated age was within $\pm$3 (Male = 39.1%, female = 43.4%), $\pm$5 (Male = 18.3%, Female = 20.5%), $\pm$10 (Male = 32.2%, Female = 27.7%) and above 10 years (Male = 10.4%, Female = 8.4%). In both sexes, a higher percentage 40.9% has estimated age $\pm$3 years, while the least 9.6% lies within above 10 years.

A larger percentage of middle-aged individuals (31 – 40) have estimated age within $\pm$3 years of their actual age, while young individuals (21 – 30) were the least. Lu *et al*[30] made similar observations, while Kim *et al*[29] reported to the contrary.

4. CONCLUSION

The study was able to evaluate occlusal tooth wear in Igbo adults stratified by age. It was established that age can be estimated from tooth wear using Kim's rating scale as modified by Lu *et al*.[30]

Tooth wear pattern or score is independent of age, as higher (above 5) and lower (less than 5) TWS were recorded for younger as well as older individuals, although the later had higher values compared to the former.

Tooth wear accurately estimated age up to 72% accuracy and will as such aid in forensic investigations, considering the availability of the teeth even after terrible taphonomic conditions.

The study will be helpful to forensic anthropologist and anatomists as an adjunct in estimating age, especially in limited resource settings and in conditions where other body parts have grossly disintegrated.

5. CONFLICT OF INTEREST

The authors report that there is no conflict of interest.

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