

# WEST AFRICAN JOURNAL OF ORTHODONTICS

ISSN 2315-9502

VOLUME 9, NUMBER 1

JUNE 2020

**Dental age estimation using panoramic radiographs**



**ODI and APDI norms for adult Nigerians**



**Maxillary midline diastema in Africa:  
Scoping review**



**Management of increased overjet  
using Tip-Edge plus**



**Bilateral cleft lip and palate treated  
with clear aligners**

# Dental Age Estimation using Panoramic Radiographs: A Study on Children in North Central Nigeria

Odunnaike OO<sup>a</sup>, Alabi AS<sup>a</sup>, Adeyemi MF<sup>b</sup>, Ernest MO<sup>c</sup>, Sanni-Abdullahi SO<sup>c</sup>

## Abstract

**Background:** Age estimation is very important in forensic medicine, not only for identification of victims, but also in crimes and accidents. This study aimed to evaluate the applicability and compare the accuracy of Demirjian, Willems I, and Willems II methods for dental age estimation in children in North central Nigeria using panoramic radiographs.

**Methods:** This study was a retrospective study of panoramic radiographs from 70 children aged 7 to 17 years from a tertiary health institution North central Nigeria. Chronological age was calculated as the difference between the date of birth and the date on which the radiograph was made. Dental age was calculated using the Demirjian, Willems I and Willems II methods.

Data was analyzed with SPSS VERSION 20.

**Results:** The chronological mean age of the boys and girls was  $10.63 \pm 2.58$  and  $11.60 \pm 3.20$  respectively. A mean difference (CA-DA) of 0.58/0.85, 0.01/0.03, 0.15/-0.11, was observed for Demirjian's, Willems I and Willems II methods for males and females respectively. The three tested methods underestimated the mean chronological age of males and females except the Willems II method which overestimated the mean age of the females.

**Conclusion:** The level of accuracy of these three methods in the children of North central, Nigerian population is acceptable. Demirjian's seven teeth method is recommended for age prediction in both sexes as it reveals highest correlation value with the chronological age. In forensic cases, when the sex is doubted, the Willems II method is appropriate.

**Keywords:** Chronological age, Dental age, Demirjian, Willems, Panoramic radiograph, Nigeria

## Authors' affiliations

<sup>a</sup>Department of Anatomy, faculty of Basic Medical Sciences college of Health sciences University of Ilorin, Nigeria.

<sup>b</sup>Department of Surgery, University of Ilorin, Nigeria.

<sup>c</sup>Department of Surgery, University of Ilorin Teaching Hospital, UITH, Ilorin,

## Correspondence

Dr MO Ernest: Department of Surgery, University of Ilorin Teaching Hospital, UITH, Ilorin.  
Email: moni.ernest@yahoo.com

## Introduction

Age estimation is very important in forensic medicine, not only for identification of victims of fatal accidents, but also carried out for reasons such as criminal cases, where the actual age is unknown and age assessment of the victim is required by the courts to make decisions. It is also used for purposes other than forensic uses, such as when birth

records are unreliable or lost, where specific aging is needed to prevent cheating in age-graded sports competitions, employment criteria, and eligibility for marriage [1] or where individuals seek favourable outcomes in civil or criminal cases and some social activities [2].

There are various methods for the age estimation. Sakhdari, et al [3] stated that age estimation from teeth by radiological analysis in both children and adolescents has wide applications in several scientific and forensic fields [3]. Forensic dentistry is defined as the use of dental science for legal purposes [3].

Different methods have been proposed to estimate dental age using permanent tooth formation. Among these is Demirjian's [4] method formulated on a sample of French-Canadian children, which

involves the assessment of eight specific stages of tooth formation of the seven left mandibular teeth. Self-weighted scores, which are numerical and derived, are assigned to each tooth stage. The scores are added together to give a dental maturity score. Separate tables of dental maturity for males and females are used to convert the maturity scores to dental age [4]. The methodology gained worldwide acceptability and became the most used method for estimation of dental age [1].

Nemsi *et al.* [5] reported that Demirjian method has consistently overestimate age across populations, and expecting more accuracy, Willems *et al.* [6] suggested a new method using Demirjian maturation stages, approved in a Belgian Caucasian population that consists of new tables for each sex [5]. The tables presented scores that are directly expressed in years, so there is no need for conversion which is known as the Willems I method. Willems's method revealed consistently more accuracy of estimating the chronological age compared to Demirjian techniques. To facilitate the identification when sex is unknown, by using the Demirjian dental maturity stages, Willems *et al.* [6] presented non-sex-specific scores known as the Willems II method. In a developing country like Nigeria, one subject of continuous discussion has been how best to estimate an individual's chronological age for clinical and forensic purposes where birth records are either unavailable or not reliable [7].

While related studies had been carried out on a (south west) Nigerian population [7-8], no systematic review has yet evaluated the applicability of these methods in this setting. Hence, this study evaluated the applicability of Demirjian, Willems I, and Willems II methods for dental age estimation using panoramic radiographs from a sample of North central Nigerian children. The objectives of the study were to evaluate the accuracy of Demirjian, Willems I and Willems II methods on the relationship of chronological age and dental age with its reliability

on panoramic radiographs and to determine the differences in dental age between the sex group using these methods. Furthermore, the study sought to compare the differences of chronological age and dental age between the sex group and to predict the chronological age formula from the data generated from the study.

### Materials and methods

This study was a retrospective study of panoramic radiographs from 70 young individuals between the ages of 7 and 17 years. These individuals are healthy Nigerian patients requesting panoramic radiograph for various purposes at the tertiary Health institution, and whose radiographs were taken as part of routine treatment between July, 2014 and December, 2019. Ethical approval was sought from ethical board of the institution. All subjects whose Orthopantomographs were available with a documented date of birth and date of radiography were retrieved from the health records and examined for eligibility for the study. Radiographs of patient(s) with the following conditions; birth dates were not accessible (37 in number), with craniofacial malformative syndromes, with image distortion or lack of clarity, showing teeth with teeth root canal treatment showing shape and position anomalies of teeth, or with any history of systemic illness that has a direct influence on teeth development also Panoramic radiographs showing absence of a particular tooth type in both quadrants of the mandible were excluded from the study. A structured questionnaire containing demographic data; chronological age, dental age, and gender was administered by the researcher. Radiographic examinations were carried out by the researcher. Orthopantomograms were recorded by means of using a KODAK Dental Imaging Software V6, 12, 21, 0 attached to the X-ray viewer and saved as JPEG images. Windows Live Photo Gallery was used to view the radiographs and adjust the size, contrast and brightness for better quality and thereafter printed out

on plain sheets. Radiographs were excluded in cases of radiographic distortion affecting the staging of the left mandibular teeth or in the incidence of dental developmental abnormalities. The radiograph was reviewed by one investigator.

The study population was classified according to chronological age (CA) into five groups of two years each as 7-8, 9-10, 11-12, 13-14 and 15-

16. The chronological age (represented in two decimal places) was determined using the difference between the date of birth (DOB) and the date on which the panoramic radiograph was taken (DODental age (DA) was assessed using three methods; Demirjian method, Willems I method and Willems II method. Each of the seven left permanent teeth of the mandible (excluding the third molar) was assessed and the stage of maturation classified as 'A' to 'H' using the Demirjian's dental staging method.

**Table 1. Radiographic and schematic illustration of the developmental stages according to Demirjian et al. [4]**

	Molars	Premolar	Canine	Incisor
A				
B				
C				
D				
E				
F				
G				
H				

When a tooth is missing on the left quadrant, the corresponding tooth on the right quadrant was used for the assessment.

All orthopantomograms (OPGs) was examined by one observer. The observer was blinded with regards to the CA and other details such as the name, DOB and gender of the patient when evaluating the radiograph. To assess the intra-observer agreement, randomly selected 10 OPGs were re-evaluated by the same examiner, following one week of initial evaluation using Demirjian's method of dental staging and without any knowledge of the stages attributed in the first evaluation. Dental ages were reassessed using Demirjian's seven teeth staging method for all three methods.

**Demirjian's Method**

Demirjian's method stages the radiographic appearance of the seven mandibular teeth on the left quadrant. The seven left mandibular permanent teeth

were staged (A-H), rated in the order of the second molar (M<sub>2</sub>), first molar (M<sub>1</sub>), second premolar (PM<sub>2</sub>), first premolar (PM<sub>1</sub>), canine (C), lateral incisor (I<sub>2</sub>) and central incisor (I<sub>1</sub>). Stages (A-H) represent the eight (8) stages of mineralization of the tooth from the beginning of calcification through to the final mature form together with stage zero for non-appearance. If there is no sign of calcification, the rating 0 is given; the crypt formation is not taken into consideration. Each stage of mineralization is given a maturity score (A-H) for each tooth (Table I) which provides an estimate of dental maturity. Each stage is then converted to a self-weighted score (Table II) separate for male and female, which is then summed up to give a total maturity score on a scale of 0-100 percentile charts, that will then be converted directly into a dental age using the standard conversion tables for male and female given by Demirjian (Tables 3A & 3B).

**Table 2. Self-weighted scores for dental stages according to the Demirjian's method [4].**

**Self-Weighed Scores for Dental Stages  
7 Teeth (Mandibular Left Side)**

Boys									
Stage	0	A	B	C	D	E	F	G	H
Tooth	0	A	B	C	D	E	F	G	H
M <sub>2</sub>	0.0	2.1	3.5	5.9	10.1	12.5	13.2	13.6	15.4
M <sub>1</sub>				0.0	8.0	9.6	12.3	17.0	19.3
PM <sub>2</sub>	0.0	1.7	3.1	5.4	9.7	12.0	12.8	13.2	14.4
PM <sub>1</sub>			0.0	3.4	7.0	11.0	12.3	12.7	13.5
C				0.0	3.5	7.9	10.0	11.0	11.9
I <sub>2</sub>				0.0	3.2	5.2	7.8	11.7	13.7
I <sub>1</sub>					0.0	1.9	4.1	8.2	11.8

Girls									
Stage	0	A	B	C	D	E	F	G	H
Tooth	0	A	B	C	D	E	F	G	H
M <sub>2</sub>	0.0	2.7	3.9	6.9	11.1	13.5	14.2	14.5	15.6
M <sub>1</sub>				0.0	4.5	6.2	9.0	14.0	16.2
PM <sub>2</sub>	0.0	1.7	3.4	6.5	10.6	12.7	13.5	13.8	14.6
PM <sub>1</sub>			0.0	3.7	7.5	11.8	13.1	13.4	14.1
C				0.0	3.8	7.3	10.3	11.6	12.4
I <sub>2</sub>				0.0	3.2	5.6	8.0	12.2	14.2
I <sub>1</sub>					0.0	2.4	5.1	9.3	12.9

NB: Stage 0 is no calcification

**Table 3A. Conversion Table of Maturity Score to Dental Age for Boys [4]**

Age	Score	Age	Score	Age	Score	Age	Score
<b>Boys</b>							
3.0	12.4	7.0	46.7	11.0	92.0	15.0	97.6
.1	12.9	.1	48.3	.1	92.2	.1	79.7
.2	13.5	.2	50.0	.2	92.5	.2	97.8
.3	14.0	.3	52.0	.3	92.7	.3	97.8
.4	14.5	.4	54.3	.4	92.9	.4	97.9
.5	15.0	.5	56.8	.5	93.1	.5	98.0
.6	15.6	.6	59.6	.6	93.3	.6	98.1
.7	16.2	.7	62.5	.7	93.5	.7	98.2
.8	17.0	.8	66.0	.8	93.7	.8	98.2
.9	17.6	.9	69.0	.9	93.9	.9	98.3
4.0	18.2	8.0	71.6	12.0	94.0	16.0	98.4
.1	18.9	.1	73.5	.1	94.2		
.2	19.7	.2	75.1	.2	94.4		
.3	20.4	.3	76.4	.3	94.5		
.4	21.0	.4	77.7	.4	94.8		
.5	21.7	.5	79.0	.5	94.8		
.6	22.4	.6	80.2	.8	95.0		
.7	23.1	.7	81.2	.7	95.1		
.8	23.8	.8	82.0	.8	95.2		
.9	24.6	.9	82.8	.9	95.4		
5.0	25.4	9.0	83.6	13.0	95.11		
.1	26.2	.1	84.3	.1	95.7		
.2	27.0	.2	85.0	.2	95.8		
.3	27.8	.3	85.6	.3	95.9		
.4	28.6	.4	86.2	.4	96.0		
.5	29.5	.5	86.7	.5	96.1		
.6	30.3	.6	87.2	.6	96.2		
.7	31.1	.7	87.7	.7	96.3		
.8	31.8	.8	88.2	.8	96.4		
.9	32.6	.9	88.6	.9	96.5		
6.0	33.6	10.0	89.0	14.0	96.6		
.1	34.7	.1	89.3	.1	96.7		
.2	35.8	.2	89.7	.2	96.8		
.3	36.9	.3	90.0	.3	96.9		
.4	38.0	.4	90.3	.4	97.0		
.5	39.2	.5	90.6	.5	97.1		
.8	40.6	.6	91.0	.6	97.2		
.7	42.0	.7	91.3	.7	97.3		
.8	43.6	.8	91.6	.8	97.4		
.9	45.1	.9	91.6	.9	97.5		

**Table 3B. Conversion Table of Maturity Scores to Dental Age for Girls [4].**

Ago	Score	Age	Score	Age	Score	Age	Serial
<b>Girl</b>							
3.0	13.7	7.0	51.0	11.0	94.5	15.0	90.2
.1	14.4	.1	52.9	.1	94.7	.1	99.3
.2	15.1	.2	55.5	.2	94.9	.2	99.4
.3	15.8	.3	57.8	.3	95.1	.3	99.4
.4	16.6	.4	61.0	.4	95.3	.4	99.5
.5	17.3	.5	65.0	.5	95.1	.5	99.6
.6	18.0	.6	68.0	.6	95.6	.6	99.6
.7	18.8	.7	71.8	.7	95.8	.7	99.7
.8	19.5	.5	75.0	.8	96.0	.8	99.5
.9	20.3	.9	77.0	.9	98.2	.9	99.9
4.0	21.0	8.0	78.8	12.0	96.3	16.0	100.0
.1	21.8	.1	80.2	.1	96.4		
.2	22.5	.2	81.2	.2	96.5		
.3	23.2	.3	82.2	.3	96.6		
.4	24.0	.4	83.1	.4	96.7		
.5	24.8	.5	84.0	.5	96.8		
.0	25.6	.6	84.8	.6	96.9		
.7	26.4	.7	85.3	.7	97.0		
.8	27.2	.8	86.1	.8	97.1		
.9	28.0	.9	86.7	.9	97.2		
5.0	28.9	9.0	87.2	13.0	97.3		
.1	22.7	.1	87.8	.1	97.4		
.2	30.5	.2	88.3	.2	97.5		
.3	31.3	.3	88.8	.3	97.6		
.4	32.1	.4	89.3	.4	97.7		
.5	33.0	.5	98.8	.5	97.6		
.6	34.0	.6	90.2	.0	98.0		
.7	35.0	.7	90.7	.7	98.1		
.8	36.0	.8	91.1	.8	98.2		
.9	37.0	.9	91.4	.9	96.3		
6.0	38.0	10.0	91.8	14.0	98.3		
.1	30.1	.1	92.1	.1	98.4		
.2	40.2	.2	92.3	.2	98.5		
.3	41.3	.3	92.6	.3	96.6		
.4	42.5	.4	92.9	.4	98.7		
.5	43.9	.5	93.2	.5	98.8		
.6	45.2	.6	93.5	.0	98.9		
.7	46.7	.7	93.7	.7	90.0		
.8	46.0	.8	94.0	.8	99.1		
.9	49.5	.9	94.2	.9	99.1		

**Willems Methods**

Willems methods consider the developmental stages of the seven left permanent mandibular teeth also using the Demirjian's staging technique of 'A' to 'H' tooth mineralization stages. A score is obtained for

each tooth from sex-specific tables for the Willems I method and from the non-sex-specific table for the Willems II method. The seven teeth, from A to H on the left quadrant of the mandible in the selected OPG, are coded as shown in Fig. 3.1 with the assistance of

the reference illustrations and radiographs given in table I. Finally, the Willems I and Willems II dental

age estimation is obtained by adding up the score corresponding to each letter code for all seven teeth as shown in Table 4.



**Figure 1:** Panoramic radiograph marked with the staging codes corresponding to the different mineralization stages of each of the seven permanent teeth of the left lower quadrant using Demirjian method

**TABLE 4. Age scores for each developmental tooth stage expressed directly in years for Willems' sex-specific and non-sex-specific methods [6].**

Developmental tooth stages according to the Demirjian's technique (1) with corresponding age scores expressed directly in years for each of the seven left mandibular teeth								
	Demirjian developmental tooth stages							
	A	B	C	D	E	F	G	H
<b>Males and Females</b>								
Central Incisor	-	-	1.87	1.88	1.97	2.40	2.71	2.74
Lateral Incisor	-	-	-0.82	-0.65	-0.57	-0.29	-0.01	0.07
Canine	-	-	1.13	1.11	1.27	1.51	1.85	2.20
First bicuspid	-0.07	0.31	0.54	0.84	1.05	1.67	2.07	2.64
Second bicuspid	-0.01	0.07	0.19	0.26	0.46	0.55	0.64	1.55
First Molar	-	-	-	0.75	1.14	1.70	1.95	2.28
Second Molar	0.17	0.32	0.50	0.61	1.04	1.79	2.25	4.42
<b>Males</b>								
Central Incisor	-	-	1.68	1.49	1.50	1.86	2.07	2.19
Lateral Incisor	-	-	0.55	0.63	0.74	1.08	1.32	1.64
Canine	-	-	-	0.04	0.31	0.47	1.09	1.90
First bicuspid	0.0015	0.56	0.75	1.11	1.48	2.03	2.43	2.83
Second bicuspid	0.08	0.05	0.12	0.27	0.33	0.45	0.40	1.15
First Molar	-	-	-	0.69	1.14			
Second Molar								
<b>Females</b>								
Central Incisor	-	-	1.83	2.19	2.34	2.82	3.19	3.14
Lateral Incisor	-	-	-	0.29	0.32	0.49	0.79	0.70
Canine	-	-	0.60	0.54	0.62	1.08	1.72	2.00
First bicuspid	-0.95	-0.15	0.16	0.41	0.60	1.27	1.58	2.19
Second bicuspid	-0.19	-0.01	0.27	0.17	0.35	0.35	0.55	1.51
First Molar	-	-	-	0.62	0.90	1.56	1.82	2.21
Second Molar	0.14	0.11	0.21	0.32	0.66	1.28	2.09	4.04

The sum of these age scores directly expresses the dental age of the patient. This way the conversion to dental age as was the case with Demirjian's method is not necessary, which is the basic modification from the Demirjian's method [6,9].

### Data Collection

The study population was classified according to chronological age (CA) into five groups of two years each as 7-8, 9-10, 11-12, 13-14 and 15-16. The chronological age (represented in two decimal places) was determined using the difference between the date of birth (DOB) and the date on which the panoramic radiograph was taken (DOR).

Dental age (DA) was assessed using three methods; Demirjian method, Willems I method and Willems II method. Each of the seven left permanent teeth of the mandible (excluding the third molar) was assessed and the stage of maturation classified as 'A' to 'H' using the Demirjian's dental staging method (table I).

When a tooth is missing on the left quadrant, the corresponding tooth on the right quadrant was used for the assessment.

All orthopantomograms (OPGs) was examined by one observer. The observer was blinded with regards to the CA and other details such as the name, DOB and gender of the patient when evaluating the radiograph. To assess the intra-observer agreement, randomly selected 10 OPGs were re-evaluated by the same examiner, following one week of initial evaluation using Demirjian's method of dental staging and without any knowledge of the stages attributed in the first evaluation. Dental ages were reassessed using Demirjian's seven teeth staging method for all three methods.

To avoid observer bias and in order not to invade the privacy of the patients under study, patients' identities were not disclosed. Instead, each patient's OPG was coded numerically from 1 to 70.

The OPGs were examined for dental maturation score for the selected teeth. The examiner was blinded to sex, name and chronological age of the

patients. The maturation scores assigned to each permanent tooth of the left mandible of selected OPGs was based on Demirjian's staging method 'A' to 'H' for all three methods.

For the Demirjian's method, dental age (DA) was assessed for a selected radiograph by observing each of the seven left permanent teeth of the mandible (excluding the third molar). Each permanent tooth was assigned a code based on its developmental stage using the Demirjian's classification of tooth mineralization stage 'A' to 'H' chart (as shown in table I). The codes for each of the seven left permanent teeth of the mandible was then assigned a maturity score using the Demirjian's self-weighted scores table (as shown in table II) separate for boys and girls. The sum of this self-weighted maturation score which is usually on a scale of 0-100 percentile charts is then converted to a dental age using the Demirjian's conversion tables (as shown in tables IIIA & IIIB) which is separate for boys and girls for the selected radiograph.

For the Willems I method, dental age (DA) was assessed by simply adding up the age scores which corresponds to each mineralization stage of the Demirjian's 'A' to 'H' chart (table 1) of each of the seven left permanent teeth of the mandible (excluding the third molar) of the selected radiograph using the Willems' sex-specific table (as shown in table IV) separate for boys and girls. The sum of these age scores directly expresses the dental age of the patient. This way the conversion to dental age as was the case with Demirjian's method is not necessary, which is the basic modification from the Demirjian's method.

For the Willems II method, dental age (DA) was assessed also by adding up the age scores which corresponds to each mineralization stage of the Demirjian's 'A' to 'H' chart (table 1) of each of the seven left permanent teeth of the mandible (excluding the third molar) of the selected radiograph, this time using the Willems' non-sex-specific table (as shown in table IV) same for boys

and girls. The sum of these age scores directly expresses the dental age of the patient just like in the Willems I method.

A function of Microsoft Excel was thereafter used to calculate the difference between the date of birth and the date on which the panoramic radiograph was made to obtain the chronological age (CA) in two decimal places.

To assess the intra-observer reliability, randomly

selected 10 OPGs were reevaluated by the same examiner, following one week of initial evaluation using Demirjian's method of dental staging and without any knowledge of the stages attributed in the first evaluation. The intraobserver reliability test using paired sample t-test was done as shown in Table 5. Dental ages were reassessed using Demirjian's seven teeth staging method for all three methods and recorded as shown in Table 7a and 7b

**TABLE 5. Intraobserver reliability test using paired sample t-test**

Pair	Mean±S.D	Pearson's Correlation		Paired Samples Test		
		r	P-value	M.D	t-value	p-value
DM-1 DM-2	10.56±2.20 10.48±1.96	0.952	<0.001	0.078	0.36	0.727
WM1-1 WM1-2	10.94±1.94 11.04±2.01	0.998	<0.001	-0.097	-2.055	0.070
WM2-1 WM2-2	10.95±1.96 11.02±1.98	0.998	<0.001	-0.072	-1.659	0.132

There were no significant different between the measurements taken at different periods by the same observer ( $P>0.05$ ), and the correlations between the pairs DM (0.952), WM1 (0.998), and WM2 (0.998) were significantly high ( $P<0.001$ ). Thus, suggesting high reliability in measurement technique (Table 5)

**Statistical Analysis**

The data collected was cleaned, edited, coded, and entered into Microsoft excel 2016. The entered data was then exported to Statistical Package for Social Sciences (SPSS) version 26 (IBM®, Amornk, USA) and STATGRAPHICS centurion CVI version 16.1.11 (Stat Point Tech., Inc.) for analysis.

Using SPSS, intraobserver reliability was estimated using paired sample t-test. The accuracy of each method of age estimation by the mean difference between chronological and dental ages (CA-DA), for each sex and age group, and the total sample. A positive result designates an underestimation, and a negative one indicates an overestimation of age. The

extent of divergence between the chronological age and estimated dental age for all tested methods was statistically evaluated using the paired sample t-test. Independent samples t-test was employed to compare the differences (CA-DA) between sexes for the three methods.

The correlation between DA and CA was analysed using Spearman's rank correlation coefficient for each method, sex and for the total sample. Comparison of regression lines was used to determine the influence of sex on the relationship between CA and the estimated DAs. The analyses were performed at 95% confidence level and p-values less than 0.05 was considered significant.

**Results**

A total of 70 (39; 55.7% males and 31; 44.3% females) subjects with ages ranging from 7 to 17 years were grouped as presented in Table 4.

Table 6 contains the Chronological Ages (CA) and

Dental Ages (DA) estimated from the orthopantomograms (OPGs) of the 70 patients under study using Demirjian's Method (DM), Willems I Method (WM1) and Willems II Method (WM2) respectively.

**Table 6. Age distribution of study population**

Age group	Male (%)	Female (%)	Total (%)
7 – 8	11 (28.2)	10 (32.3)	21 (30.0)
9 - 10	12 (30.8)	5 (16.1)	17 (24.3)
11 - 12	8 (20.5)	4 (12.9)	12 (17.1)
13 - 14	5 (12.8)	6 (19.4)	11 (15.7)
15 - 16	3 (7.7)	6 (19.4)	9 (12.9)
	<b>39 (55.7)</b>	<b>31 (44.3)</b>	<b>70 (100)</b>

The chronological mean age (CA) of the boys and girls was 10.63±2.58years and 11.60±3.20years respectively. A mean difference (CA-DA) of 0.58/0.85, 0.01/0.03, 0.15/-0.11 was observed for Demirjian's method (DM), Willems I (WM1) and Willems II (WM2) methods for males and females respectively as shown in Table 7 a and 7 b for males and females respectively. This result showed that the

mean chronological age of both the males and the females were underestimated in all three tested methods except for the Willems II method which overestimated the mean age of the females. The mean difference was highly significant (p<0.001) in males and very highly significant in females (p<0.0001 for Demirjian's method, while the mean difference was not significant (p>0.05) in both males and females for the Willems I and II methods.

**Table 7A. Mean (S.D) and mean difference (md) between C.A and the estimated DAs using DM, WM1 and WM2 in males**

Age Group	N	CA	DM	CA vs DM md (p-value)	WM1	CA vs WM1 md (p-value)	WM2	CA vs WM2 md (p-value)
7 to 8	11	7.90±0.49	8.20±0.51	-0.30(0.128)	8.41±0.47	-0.51(0.022)*	8.08±0.52	-0.18(0.413)
9 to 10	12	9.67±0.59	9.23±0.69	0.44(0.107)	9.86±1.00	-0.19(0.577)	9.63±0.99	0.04(0.905)
11 to 12	8	11.73±0.65	10.08±0.86	1.65(0.001)**	11.43±1.11	0.30(0.502)	11.43±1.35	0.30(0.580)
13 to 14	5	14.01±0.59	12.71±0.88	1.30(0.025)*	13.24±0.91	0.77(0.151)	13.46±1.13	0.55(0.363)
15 to 16	3	15.86±0.77	15.57±0.75	0.29(0.670)	15.20±1.44	0.66(0.523)	15.16±1.28	0.70(0.463)
<b>Total</b>	<b>39</b>	<b>10.63±2.58</b>	<b>10.05±2.23</b>	<b>0.58(0.001)**</b>	<b>10.62±2.25</b>	<b>0.01(0.964)</b>	<b>10.48±2.43</b>	<b>0.15(0.340)</b>

CA: Chronological Age, DA: Dental Age, DM: Demirjian Method, WM1: Willems I Method, WM2: Willems II Method

\*\*\*p-value <0.001, Very highly significant difference

\*\*p-value <0.01, Highly significant difference

\*p-value <0.05, Significant difference

p-value ≥0.05, Non-significant difference

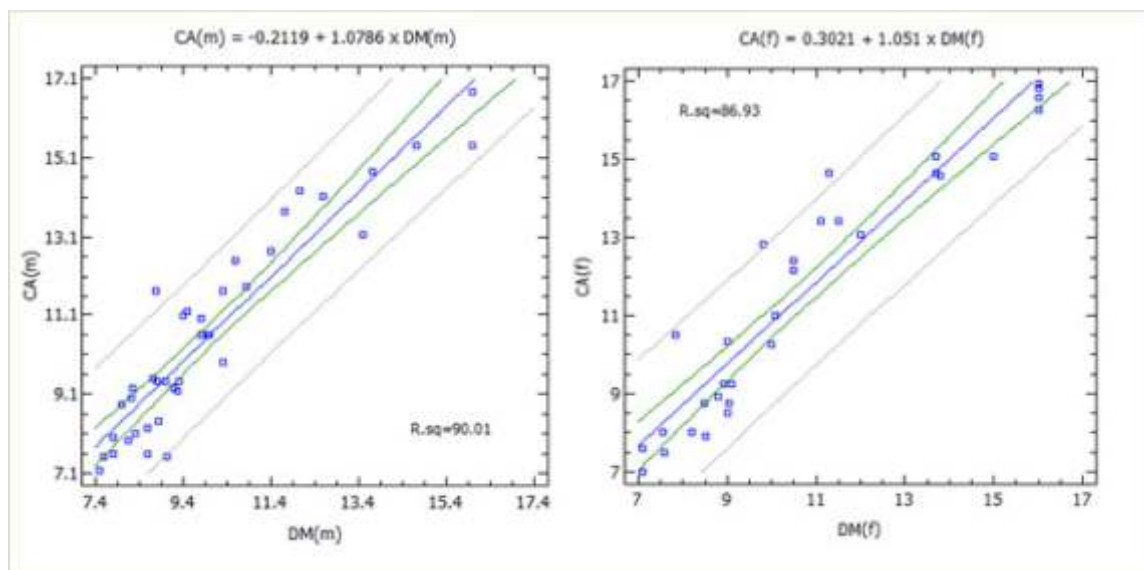
**Table 7B. Mean (S.D) and mean difference (md) between C.A and the estimated DAs using DM, WM1 and WM2 in males**

Age Group	N	CA	DM	CA vs DM md (p-value)	CA vs WM1 md (p-value)	CA vs WM2 md (p-value)
7 to 8	10	8.09±0.63	8.13±0.75	-0.04(0.894)	8.01±0.87	0.08(0.807)
9 to 10	5	9.92±0.61	8.96±0.78	0.69(0.132)	11.83±4.29	-1.91(0.353)
11 to 12	4	12.11±0.79	10.23±0.34	1.88(0.005)**	11.89±0.68	0.22(0.688)
13 to 14	6	13.97±0.74	12.24±1.21	1.73(0.014)*	13.37±1.12	0.60(0.325)
15 to 16	6	16.12±0.84	15.45±0.95	0.67(0.225)	15.26±0.92	0.86(0.122)
<b>Total</b>	<b>31</b>	<b>11.60±3.20</b>	<b>10.75±2.89</b>	<b>0.85(&lt;0.001)***</b>	<b>11.57±3.27</b>	<b>0.03(0.927)</b>

CA: Chronological Age, DA: Dental Age, DM: Demirjian Method, WM1: Willems I Method, WM2: Willems II Method  
 \*\*\*p-value <0.001, Very highly significant difference      \*p-value <0.05, Significant difference  
 \*\*p-value <0.01, Highly significant difference              p-value ≥0.05, Non-significant difference

All tested methods revealed an underestimation of age (except the 7-8 and 9-10 age groups where an overestimation of age was sometimes observed) in both sexes. The application of Demirjian's method revealed statistically significant differences among the 11-12 and 13-14 age groups in both males and females, while only age group 7-8 in males showed a significant difference for the Willems I method.

The correlations between the chronological age (CA) and the estimated dental age (DAs) using DM, WM1, and WM2 for males and females were presented in Figs. 1, 2, and 3 respectively. The scatter plot graph showed a strong positive correlation between the two measures. The R<sup>2</sup> values were 0.900 (male) and 0.869 (female) for DM, 0.876 (male) and 0.705 (female) for WM1 and 0.866 (male) and 0.693 (female) for WM2.



**Figure 2:** Correlation between C.A and the DM estimated age

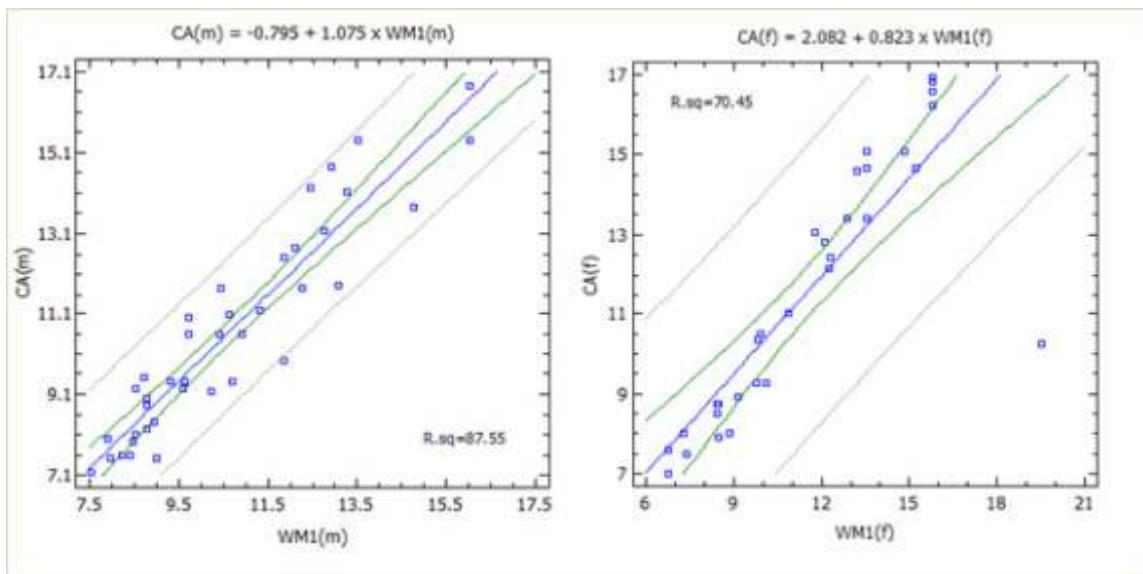


Figure 3 : Correlation between C.A and the WM1 estimated age

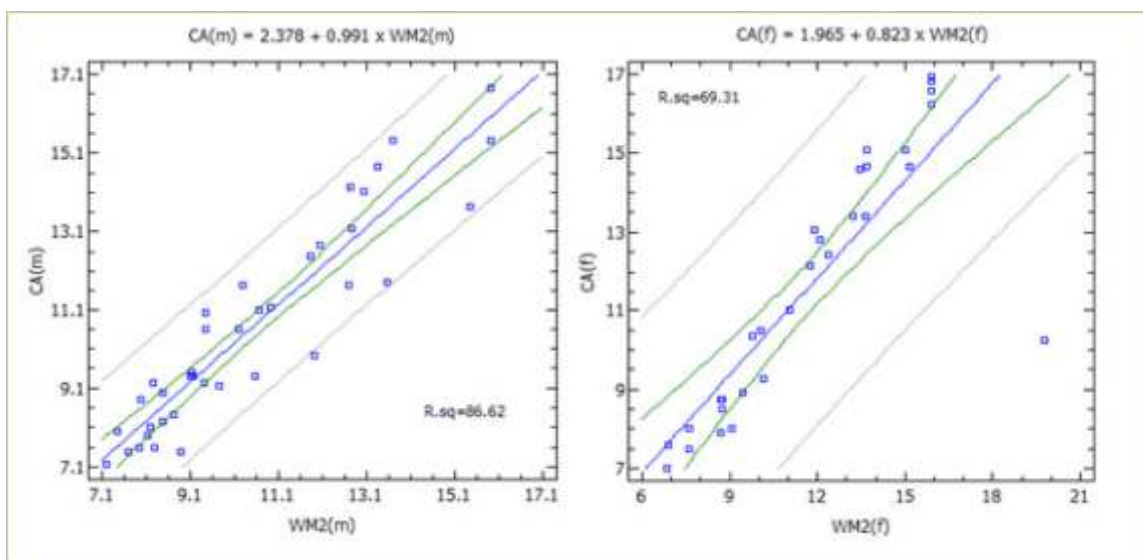


Figure 4 : Correlation between C.A and the WM2 estimated age

A prediction equation was also formulated and the suggested formulas for age prediction according to the interpreted data are as follows:

The equation for Demirjian's method:

Males:  $CA = -0.2119 + 1.0786 \times DM$   
 Females:  $CA = 0.3021 + 1.051 \times DM$

The equation for Willems I method:

Males:  $CA = -0.795 + 1.075 \times WM1$   
 Females:  $CA = 2.082 + 0.823 \times WM1$

The equation for Willems II method:

Males:  $CA = 2.378 + 0.991 \times WM2$   
 Females:  $CA = 1.965 + 0.823 \times Wm2$

From the result in Table 4.3, the slope and intercepts for DM and WM2 were not significantly different between male and female ( $P > 0.05$ ), though the predictions are significant ( $P < 0.01$ ). On the other hand, the slope for WM1 was significantly different for the sexes ( $P = 0.0461$ ) with significant predictions ( $P < 0.001$ ).

**Table 8. The ANOVA for sex in the order fitted regression model**

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
<b>DM</b>	513.217	1	513.217	529.83	<0.001
Intercepts	0.883	1	0.883374	0.91	0.3431
Slopes	0.082	1	0.082331	0.08	0.7716
Model	514.182	3			
<b>WM1</b>	447.667	1	447.667	241.01	<0.001
Intercepts	0.175	1	0.175285	0.09	0.7597
Slopes	7.677	1	7.67724	4.13	0.0461
Model	455.519	3			
<b>WM2</b>	445.681	1	445.681	228.95	<0.001
Intercepts	0.247	1	0.247244	0.13	0.7227
Slopes	3.709	1	3.70899	1.91	0.1721
Model	449.637	3			

DM: Demirjian Method, WM1: Willems I Method, WM2: Willems II Method  
*p*-value <0.001, Significant difference  
*p*-value ≥0.05, Non-significant difference

**Discussion**

Ideally, age estimation in a population should be done by using different methods presented by existing literatures and practices, as well as the development of new methods to ensure the application of the most adequate technique [10].

This study aimed to evaluate the applicability and compare the accuracy of the Demirjian, Willems I and Willems II radiographic methods of estimating dental age of children in an Ilorin population for application in forensic medicine, pediatric dentistry and orthodontics.

In the majority of studies done using the Demirjian's seven teeth method, an overestimation of the chronological age was observed and was explained by a positive secular trend in growth and development during the last decades [5]. We cannot admit the same explanation for this study, which revealed an overall underestimation for the three tested methods (except in the younger age groups 7-8 and 9-10 where an overestimation of age was sometimes observed) for both sexes. This finding agreed with a previous study done on a Tunisian

sample which revealed a noticeable overestimation for ages ranging from 3 to 8 years and a high underestimation for ages varying from 9 to 16 years using Demirjian's seven teeth method [11] and also on a Jordanian sample where dental maturity is advanced in young age groups and delayed in older ones [12]. The overall underestimation of chronological age could be due to a real delay of development of premolars and molars in the Ilorin population compared to the French-canadian one.

This study revealed that CA of the examined females were more underestimated compared to their male counterparts when using the Demirjian's technique (mean differences between EDAs and CAs of 0.58 and 0.85 years for males and females, respectively), hence suggesting sexual dimorphism. On the contrary, a previous study on a Nigerian population revealed that males were more dentally ahead of their CA than their female counterparts [8] which is similar to the findings in a population of Egyptian children where an overestimation of CA in both sexes by 0.466 years in the male group and 0.325 years in the female group was also observed [13]. This suggests the need for more population-specific age estimation studies of the Nigerian population.

Previous studies [14] have shown that tooth development varies in different populations and requires population specific studies. Studies of different ethnic populations gave different age estimates. Esan *et al.*, [10] stated that the reason for the variation among groups is not fully understood, although several explanations involving the interplay of genetic and environmental factors have been proposed.

The findings in this study also showed a very strong correlation between the chronological age and dental age, in both sexes for all three methods. No significant mean age difference was observed for both sexes using Willems I and Willems II methods.

The extent of the difference however observed in Demirjian's method (0.58(males) and 0.85 (females) which was statistically significant for both sexes was sufficient enough to cast doubts upon the utility of Demirjian's method for North central Nigerian population. This is similar to a study on northern Chinese children by Zhai *et al.* [15] but is in slight contrast to a previous study on a Nigerian population which revealed a significant difference in CA and DA among the males, but converse was the case among the female children [8].

The strong correlation however observed between the chronological age and dental age means that Demirjian's method can indeed still be used to validly estimate the dental age of Ilorin children.

Willems's methods revealed consistently more accuracy of estimating the chronological age (with a mean difference of 0.01/0.03 (Willems I) and 0.15/0.11 (Willems II) for males and females respectively) compared to Demirjian techniques (with a mean difference of 0.58/0.85 for males and females respectively). Willems I method yielded a higher accuracy in males, while the non-sex-specific scored Willems II method yielded higher accuracy in females which is similar to Hedge *et al.* [16] results on an Indian population of children aged 5-16 years

and Altan *et al.* [17] study on the Turkish population [18]. However, the Willems II method overestimated age in the females in this study which is similar to findings revealed in a population of Serbian children [19], Indian children [16] and Egyptian children [20]. Of all the methods, the one that has been extensively used is Demirjian's method which is simple and practical as it clearly defines the stages of tooth development thereby leading to minimal inter and intra-observer variability.

Although the current results and other reports have suggested that Demirjian's method can be unsuitable as a forensic age estimation tool, Demirjian's method is still a recommended method to assess individual dental maturity. Notably, no method has the ability to accurately determine the exact CA, because differences between the estimated dental age (EDA) and CA appear, not only due to the accuracy of the applied method but also due to other factors, such as the examiners' skills and experience, the studied sample size and distribution, developmental and environmental variability between the studied subjects themselves, and the methods used to analyze and interpret the obtained results [13].

Although, our sample size appears small compared to those of similar studies, a small sample size is not considered a limitation in forensic scientific research.

## Conclusion

In conclusion, Willems' methods are absolutely more accurate in the North central Nigerian population. Also, the level of accuracy of these three methods in the Ilorin population is acceptable. Although, significant differences between the estimated dental age and chronological age was observed with the Demirjian's method for both sexes, all methods could be relatively applicable to estimate age in an Ilorin population. However, for more accuracy, it will be judicious to use the most appropriate method, according to the results obtained, by sex. In forensic cases, when the sex is unknown or doubted, the Willems II method is appropriate.

### Author's Contributions.

Conceived and designed by: OOO, all the other authors contributed substantially to data collection, analysis, and write up. All authors approved the final manuscripts.

### Funding/Grants

Funded by the authors.

### References

1. Esan T, Yengopal V, Schepartz L. The Demirjian versus the Willems method for dental age estimation in different populations: A meta-analysis of published studies. *PLoS ONE*. 2017;12(11).
2. Sakhdari S, Mehralizadeh S, Zolfaghari, M, Madadi M. Age estimation from pulp/tooth area ratio using digital panoramic radiography. *J. Islam. Dent Ass. Ira*. 2015;27(1): 19-20.
3. Sanskriti K, Jemish A, Priyanka S. Dental age estimation by Demirjian's and Nolla's method in children of Jorpati, Kathmandu. *J. Col. Med. Sci.-Nepa*. 2018;14(3): 137-140.
4. Demirjian A, Goldstein H, Tanner J. A new system of dental age assessment. *Hum. Bio.* 1973;45(2): 211-227.
5. Nemsı H, Daya M, Salem N, Masmoudi F, Bouanène I, Maatouk F, Aissaoui A, Chadly, A. Applicability of Willems methods and Demirjian's four teeth method for dental age estimation: Cross sectional study on Tunisian sub-adults, *Forens. Sci. Intern.* 2018;291: 281. Available from: [doi.org/10.1016/j.forsciint.2018.08.007](https://doi.org/10.1016/j.forsciint.2018.08.007)
6. Willems G, Olmen A, Spiessens B, Carels C. Dental age estimation in Belgian children: Demirjian's technique revised. *J. Forens. Sci.* 2001;46: 893-895.
7. Olaopa O, Gbolahan O, Okoje V, Mellikam S, Oyelaran P. Comparative analyses of three radiographic dental age estimation methods amongst Nigerians. *Nig J. Med.* 2019;28(4): 403-412.
8. Ifesanya J, Adeyemi A. Accuracy of age estimation using Demirjian method among Nigerian children. *Afri. J. Med. and Med. Sci.* 2012;41: 1-4.
9. Willems G, Thevissen P, Belmans A, Liversidge H. Willems II. Non-gender-specific dental maturity scores. *Foren Sci. Intern.* 2010;201: 84-85.
10. Mohammed R, Krishnamraju P, Prasanth P, Sanghvi P, Reddy M, Jyotsna S. Dental age estimation using Willems method: A digital orthopantomographic study. *Contemp. Clinical Dentistry*. 2014;5(3): 371-376.
11. Aissaoui A, Salem N, Mougou M, Maatouk F, Chadly A. Dental age assessment among Tunisian children using the Demirjian method. *Journal of Forensic Dental Sciences*. 2016;8(1): 47-51.
12. Abu-Alhaija E, Owais A, Aljamal G, Nasrawi Y. Dental age estimation of Jordanian children: Applicability of Demirjian method. *RGO, Revista Gaúcha Odont.* 2019; 68.
13. Moness-Ali A, Ahmed W, Khatlab M. Applicability of Demirjian's method for dental age estimation in a group of Egyptian children. *BDJ Open*. 2019;5(2): 1-5.
14. Guldane M, Sevgi O. Age estimation based on the third molar development in a turkish population: A radiographic study. *Annals Med. Res.* 2019; 1-2.
15. Zhai Y, Park H, Han J, Wang H, Ji F, Tao J. Dental age assessment in a northern Chinese population. *J. Forens Leg. Med.* 2016;38: 43-49.
16. Hedge S, Patodia A, Dixit U. Willems I vs Willems II: a comparative study of accuracy in 5-15 year old indian children. *Forens. Sci. Intern.* 2016;266: 117-122.
17. Altan H, Altan A, Bilgic F, Sozer O, Damlar I. The applicability of Willems' method for age estimation in southern Turkish children: a preliminary study. *J. Forens. Leg. Med.* 2016;38: 24-27.
18. Kis H, Gorurgoz C, Basol M, Canger E, Oztas B. Evaluation of the Willems and Cameriere's dental age estimation methods in Turkish children: a modified version of Cameriere's method. *Forens. Sci. Intern.* 2020; 2.
19. Djukic K, Zelic K, Milenkovic P, Nedeljkovic N, Djuric M. Dental age assessment validity of radiographic methods on Serbian children population. *Forens. Sci. Intern.* 2013;231(1): 398.
20. EL-Bakary A, Hammad S, Ibrahim F. Comparison between two methods of dental age estimation among Egyptian children. *Mansoura J. Forens. Medical Clin. Tox.* 2009;17: 75-86.

### Conflict of Interest

None declared

### Acknowledgement

We wish to thank all the support staff for their assistance with data collection.

## Instructions for Authors

West African Journal of Orthodontics is a peer-reviewed journal published by affiliated Orthodontic Groups and Associations in the West African Sub region. The journal gives priority to reports of outstanding clinical and experimental and epidemiological works on malocclusion, dento-facial defects as well as important contributions related to common orthodontic problems in children, adolescents and adults worldwide.

### Submission

Manuscripts and registered letters should be sent to: the Editor, West African Journal of Orthodontics, Department of Child Dental Health, Faculty of Dentistry, College of Health Sciences Obafemi Awolowo University, Ile-Ife, Osun State. Nigeria.

Manuscripts in MS word attachments may also be submitted via Email to [wajoeditorinchief@yahoo.com](mailto:wajoeditorinchief@yahoo.com), in addition to hard copies. Tables, figures and text should be included in the same file if possible. Authors may submit their research works by email only; such manuscripts need not be simultaneously sent by post.

However, photographs and/or figures need to be sent separately as hard copy (under figures and illustrations).

### Acceptance

Manuscripts should meet the following criteria: original material, clear writing, appropriate study methods, valid data, and reasonable conclusions supported by the data, in short, they should contain important information on topic of general orthodontic interest.

### Peer-review Process

All the manuscripts that adhere to its style and Instructions for Authors are referred to peer-review. Some of them are rejected immediately after an inhouse review. The rejection at this stage is due to insufficient originality, serious scientific flaws or absence of message. The remaining articles are sent to at least two reviewers who are experts in the subject. Manuscripts are reviewed with due respect for authors' confidentiality, and the identity of peer reviewers is also kept confidential. A decision is made from 6 to 12

weeks according to the response from reviewers, revision by the author(s) and reappraisal on the revision.

The accepted manuscripts are subjected to editorial revision to comply with the requirements on language and style of the journal. The rejected manuscript is not returned to authors but its copies are kept for 3 months to answer any queries. The copyright of the accepted and published articles is held by the journal and all the published materials cannot be reproduced or published elsewhere, in whole or part, without the written permission from the editor.

### Duplicate Submission

Manuscripts are considered with the understanding that they have not been published previously and are not under consideration by another publication. The author should alert the editor if the work includes subjects about which a previous report has been published. A research paper submitted to this journal should not overlap by more than 10% with the previously published material or work submitted elsewhere, which would be considered as duplicate publication. If in doubt, authors may forward copies of the published work or material submitted elsewhere to this journal for decision making.

### Proofs and Reprints

The corresponding author of the accepted article shall be supplied with the proof. Corrections on the proof should be restricted to errors only and no substantial additions/deletions should be made. No addition or deletion in the names of the authors is permissible at this stage. A copy of the issue carrying the article is supplied free of charge to the authors.

Reprints may be ordered on payment in advance.

### Categories of Articles

Articles can be sent as editorials, original articles, review articles, special communications, brief reports, case reports, letters to editor, commentaries, or for images section.

address. They are mostly included under Events of Interest free of cost. This journal reserves the right to be selective in publishing these announcements.

### **Preparing Manuscripts**

Manuscripts should be prepared in accordance with the Uniform Requirements for Manuscripts submitted to Biomedical Journals. 2 A summary of technical requirements for preparing the manuscript is provided below:

- Three copies of the manuscript should be submitted.
- Use 1 side of standard size 21.6x27.9 cm A4, white bond paper, with margins of at least 2.5 cm on each side.
- Double-space throughout including title page, abstract, text, acknowledgements, references, tables and figure legends. Start each of these sections (in same order) on a new page, numbered consecutively in the upper right hand corner, beginning with the title page.
- Use at least 12 point font size (Times New Roman or Arial).
- Submit photographs and transparencies in a separate heavy paper envelope (enclosed in cardboard, to prevent bending during mail handling).
- Conventional units are preferred with SI units in parenthesis, if available. The metric system is preferred for the expression of length, area, mass and volume.
- Use nonproprietary names of material rugs, devices and other products.
- All manuscripts should be accompanied by a signed statement by all authors regarding authorship, responsibility, financial disclosure and acknowledgements, as per standard format (Appendix J)[23 1 Those sending their manuscript through email are also required to submit this form by post with original signatures.

Manuscripts not fulfilling the technical requirements shall be returned to the authors without initiating the peer-review process.

### **Title Page**

The page should contain (i) the title of the article: which should be concise but informative (simpler the title the better; preferably it should contain all the key words to help electronic retrieval reliably); (ii) a short

running title of less than 40 characters placed at the foot end of the title page; (iii) initials and surname of each author with the highest academic degree(s) and designation at the time when the work was done; (iv) details of the contribution of each author; (v) name of department(s) and institution(s) to which the work should be attributed; (vi) disclaimers, if any; (vii) name, address, telephone, fax, email address of the corresponding author, (viii) source(s) of support in the form of grants, equipment, drugs or all of these; and (ix) declaration on competing interests.

### **Authorship**

All persons designated as authors should qualify for the authorship. Authorship credit should be based on substantial contributions to (i) concept and design, or acquisition of data, or analysis and interpretation of data; (ii) drafting the article or revising it critically for important intellectual content; and (iii) final approval of the version to be published. Conditions 1, 2 and 3 must all be met. Participation solely in the acquisition of funding or the collection of data does not justify authorship. All such people who contributed to the work but do not satisfy all the conditions should be listed in the acknowledgements.

Authors are responsible for obtaining written permissions from everyone acknowledged by name. One of the authors shall act as guarantor of the paper and he/she should take the responsibility for the integrity of the work as a whole, from its inception to published article.

Authors should provide a description of what each author contributed on the title page. Subsequently, no names can be added or deleted without written permission of the editor. Written consent of authors whose names are being deleted should be obtained.

This journal reserves the right to satisfy itself regarding the specific role of each listed author to justify authorship. All authors must give signed consent to publication (Appendix 1).

### **Competing Interest**

Competing interest for a given manuscript exists when the author has ties to activities that could inappropriately influence his or her judgment, whether or not judgment is in fact affected. Financial relationships with industry for example, through employment, consultancies, stock ownership, honoraria, expert testimony, either directly or through immediate family, are usually considered to be the most important competing interests. However, conflicts can

---

## **Original Article**

Original articles should report original research relevant to basic and clinical orthodontics including randomized trials, intervention studies, studies of screening and diagnostic tests, cohort studies, cost effectiveness analyses and case control studies. While reporting randomized controlled trials (RCT), authors must attempt to be in conformity with the consolidated standards of reporting trial.

## **(CONSORT) statements**

Each manuscript should be accompanied with a structured abstract (divided into background, methods, results and conclusions) in no more than 250 words. Four to five key words to facilitate indexing should be provided in alphabetical order along with the abstract. The text should be divided in sections on introduction, methods, results, discussion and conclusion.

Acknowledgment section may be included where necessary. Number of tables and figures should be limited to the very relevant ones and may be compressed if necessary. The typical text length for such contributions is 2500-3 500 words (excluding title page, abstract, tables, figures, acknowledgments and references).

## **Brief Report**

Short accounts of original studies are published as brief reports. The text should be divided into sections, i.e., abstract, introduction, methods, results and discussion.

Abstract should be of 100-150 words highlighting the aims, methods and main results along with 3-4 key words.

The text should contain no more than 1500 words, 3 illustrations or tables and up to 20 references, preferably recent publications.

## **Review Article**

State-of-the-art review articles or systematic, critical assessments of literature are also published. Normally a review article on a subject already published in the West African Journal of Orthodontics is not accepted for a period of 3 years.

The typical length for review articles is 2000-3000 words, excluding tables, figures, and references.

Authors submitting review manuscripts should include a structured abstract of around 200 words describing the need and purpose of review, methods used for selection, extraction and synthesis of data, and main conclusions.

Clinical cases highlighting uncommon malocclusion condition, orthodontic treatment techniques are published as case reports. Single case reports are usually not accepted, unless some new or unusual aspect regarding aetiopathogenesis, diagnosis or management is brought out that adds to the existing body of knowledge. The text should not exceed 1000 words and is divided into sections, i.e., abstract, introduction, case report and discussion. The number of tables/figures should be limited to 2. Ten recent references are acceptable. A maximum of 3 or 1 author is permitted from the principle and each of the associated departments respectively. Thus, case reports from only one investigative department can have a maximum of 3 authors.

## **Letter to Editor(s)**

Letters commenting upon a recent article in the West African Journal of Orthodontics are welcome.

Such letters should be received within 6 months of the article's publication. At the editorial board's discretion, a letter may be sent to authors! experts for comments and both letter and reply may be published together. Letters may also relate to other topics of interest to orthodontists and others, and/or useful clinical observations. Letters should not be more than 400 words. The number of authors should not exceed 2, including the authors' reply in response to a letter commenting upon an article published in this journal.

## **Images Section**

A short text of about 150 words depicting the condition with color photographs (vide infra) is needed.

Normally only clinical photographs are accepted but accompanying skiagrams or pathological images could also be considered for publication.

Photographs should be of high quality, clearly identify the condition and preferably add to the existing knowledge.

## **Personal Viewpoint**

Such articles are published on topical orthodontic issues including social aspects. It is expected that the authors have sufficient credible experience on the subject for giving viewpoints. These should not exceed 1500 words.

## **Notes, News and Events of Interest**

Announcements for conferences, symposia, meetings or courses may be sent for publication in advance. The announcements should provide title, date(s) and place of the event and contact address, telephone, and email

occur for other reasons, such as personal relationships, academic competition and intellectual passion. If any of the authors have accepted reimbursement for attending symposium, a fee for speaking, fee for organizing educational reach, funds for a member of the staff of consultation fees from an organization that may in: way gain or lose financially from the result of the study, review, editorial or letter, a competing interest would be deemed to exist. If any of the authors had been employed by an organization that may in any way gain or lose financially from the publication, or if any of them hold stocks or shares in such an organization, competing interest would be deemed to exist. If competing interest exists, the author(s) must disclose them while submitting the manuscript.

### **Abstract and Key Words**

The second page should carry an abstract in case of original article (250 words), review article (200 words), brief report (100-150 words), and case report (50 words), respectively. For original article and reviews, the abstract should be structured as detailed earlier. For brief reports, the abstract should state the purpose of the study, basic methodology, main findings (giving specific data and statistical significance) and key conclusion(s). Below the abstract, authors should provide 3-5 key words for indexing; terms from the Medical Subject Headings (MESH) list of Index Medicus should be used. The basic structure of a paper follows the well known acronym IMRAD, which stands for Introduction (what questions was asked), Methods (how was it studied), Results (what was found) and Discussion<sup>4</sup>.

### **Introduction**

The introduction must clearly state the question that the author(s) tried to answer in the study. It may be necessary to briefly review the relevant literature. Only cite those references that are essential to justify the proposed study.

### **Materials and Methods**

The methods section should describe, in a logical sequence, how the study was designed (e.g., how randomization was done), carried out (e.g., how subjects were chosen or excluded, ethical considerations, accurate details of materials used, exact drug dosage and form of treatment, etc.) and data were analyzed (e.g., an estimate of the power of the study, exact test used for statistical analysis, etc.). For standard methods, appropriate references are sufficient, but if standard methods are modified these should be clearly brought out.

Authors should provide complete details of any new methods or apparatus used (manufacturer's name and address in parentheses).

### **Ethics**

When reporting experiments on human subjects, authors should indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1964, as revised in 2000.

They should indicate whether the study was approved by the Institutions' Ethical Committee, and whether informed consent was obtained from the study participants. They should not use patients' names, initials, or hospital numbers, especially in illustrative material. This journal reserves the right to reject a manuscript on ethical grounds, on the basis of recommendations of its "Ethical Committee", even if the research has been cleared by the institutional ethical committee. Moreover, when reporting experiments on animals, authors should indicate whether the institutional and national guide for the care and use of laboratory animals was followed.

### **Statistics**

Authors should describe statistical methods with enough detail to enable a knowledgeable reader with access to the original data to verify the reported results. When possible, they meet to quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Actual P values are provided rather than stating as just  $<0.05$  or  $>0.05$  etc. References for the design of the study and statistical methods should be to standard works when possible (with pages stated) rather than to papers in which the designs or methods were originally reported. Any general-use computer programs used should be specified and statistical terms, abbreviations, and most symbols be defined.

### **Results**

This section should include only relevant, representative data and not all information collected during the study. Major findings should be presented clearly and concisely. Text, tables, and illustrations should be used sensibly while avoiding repeating in the text all the data depicted in the tables or illustrations and emphasizing or summarizing only important observations. Tables and figures should be restricted to those needed to explain the argument of the paper and to assess its support. It is necessary to cite the tables in the text and type them on separate sheets. It may also be useful to mention what the study did not find.

## Discussion

Discussion ordinarily should not be more than one third of the total length of the manuscript. This section should include a summary of the major findings, their relationship to other similar studies, limitations of methods and implications of these findings in future research. Conclusions should be linked to the goals of the study. Unqualified statements and conclusions which are not completely supported by the data should be avoided. Authors should also refrain from making statements on economic benefits and costs unless their manuscript includes economic data and analyses.

## Acknowledgements

In acknowledgements section, it is suitable to list all contributors who do not meet the criteria for authorship, such as a person who provided purely technical help, writing assistance, or a department head who provided only general support. Financial and material support should also be acknowledged.

Groups of persons who have contributed materially to the paper but whose contributions do not justify authorship may be listed under a heading such as "clinical investigators" or "participating investigators", and their function or contribution should be described, for example, "served as scientific advisers", "critically reviewed the study proposal", "collected data", or "provided and cared for study patients". A written consent is required from all the persons acknowledged, indicating their acceptance for the same.

## Contributions to joint-authorship

In the case of multiple author-ship, authors are expected to state clearly their contributions to the paper being considered for publication in terms of study initiation, design including methodology, data collection, analysis and final write-up. The editorial board reserves the right to remove any author's name if the contribution is insignificant.

## References

References should be numbered consecutively in the order in which they are first mentioned in the text.

References are identified in text, tables, and legends by Arabic numerals in parentheses. References cited only in tables or in legends to figures should be numbered in accordance with the sequence established by the first identification in the text of the particular table or figure.

The titles of journals should be abbreviated according to the style used in Index Medicus. Authors are required not to use abstracts, unpublished observations and personal communications as references. References to papers accepted but not yet published should be designated as "in press"; authors should obtain written permission to cite such papers as well as verification that they have been accepted for publication.

The references must be verified by the author against the original documents. The Uniform Requirements style (the Vancouver style) is based largely on an American National Standards Institute (ANSI) standard style adapted by the NLM for its databases.

## Journal Article

List all authors when 6 or less. When 7 or more, list only first six and add et al. Ngan P, Yiu C, Hu A, Hagg U, Ei SHY, Gunel E. Cephalometric and occlusal changes following maxillary expansion and protraction. *Eur J Orthod* 1998; 20: 237-254.

## Organization as Author

Australian Dental Association Inc. An Australian Schedule of Dental Services and Glossary. 7th edn. Sydney: Australian Dental Association Inc., 1996.

## Complete Book

Department of Health. Shifting the balance of power within the NHS: securing delivery. London: Doll, 2001.

Clayton D, Hills M. Statistical models in epidemiology. Oxford: Oxford University Press, 1993.

Farkas LG. Anthropometry of the Head and Face, 2nd Edn, New York; Raven Press; 1994

Book Chapter Lekholm U, Zarb GA. Patient selection and preparation. In: Branemark P1, Zarb GA, Albrektsson T, editors.

Tissue integrated Prostheses: Osseointegration in Clinical Dentistry, Chicago: Quintessence; 1988,199-209

## Thesis and Dissertation

Yong SJ. Bone mineral density of normal Korean adults. Ph.D. Thesis. Seoul, Korea; 1989 Anozike, AN. Orthodontic treatment needs and its impact on oral health related quality of life in Lagos school children aged 12-16 years. FMCDs. Dissertation. Lagos, Nigeria; 2006

### **Conference Proceedings**

Marshall SJ, Rixon RC, Whiteford DN, Cumming JT. The OrthoForm 3-Dimensional Clinical Facial Imaging System. Proceedings of the 15th IFHE Congress 1998; 15:83-87.

### **Dictionary and Similar References**

Stedman's medical dictionary. 26th ed. Baltimore: Williams & Wilkins; 1995. Apraxia; p.11 9-120. Unpublished accepted material Leshner AI. Molecular mechanism of cocaine addiction. N Eng J Med. In Press 1996.

### **Material from Internet**

World Health Organization, 2002.  
www.who.int/mental-health/prevention/suicide (accessed August 1, 2004).

### **Tables**

Each table should be typed in double-space on a separate sheet of paper. Tables not submitted as photographs must be numbered consecutively (Arabic numerals) in the order of their first citation in the text, with a brief but self explanatory title for each.

Each column should have a short or abbreviated heading. Explanatory matters are placed in footnotes, not in the heading. In footnotes all nonstandard abbreviations that are used in each table should be explained adequately. Statistical measures of variations should be identified such as standard deviation and standard error of the mean. Be sure that each table is cited in the text. If data are used from another published or unpublished source, it is necessary to obtain permission and acknowledge them fully.

### **Figures and Instructions**

Figures should be professionally drawn and photographed; freehand or typewritten lettering is unacceptable. Instead of original drawings, X-ray films, and other material, sharp, glossy, black-and-white photographic prints of high quality are necessary, usually 127x 173 mm (5x7 in) but no larger than 203x254 mm (8x10 in) For color illustrations negatives or positive transparencies are provided, along with color prints. It is preferable to have the photograph in portrait form rather than in landscape form to fit easily into one column. Letters, numbers and symbols in photographs should be clearly legible.

Each figure should have a label pasted on its back indicating the number of the figure, author's name, and an arrow to mark the top and left side of the figure.

It is unacceptable to write on the back of figures or scratch or mark them by using paper clips, and to bend figures or mount them on cardboard. If photographs of individual/people are used, either the subjects must not be identifiable or their pictures must be accompanied by written permission to use the photograph. It is advisable to cover the eyes unless specifically need to be shown. If a figure has been published, the original source should be acknowledged and written permission from the copyright holder be obtained to reproduce the material. Figures should be numbered consecutively (Arabic numerals) according to the order in which they have been first cited in the text.

### **Legends for Illustrations**

Legends for illustrations should be typed or printed out in double-space, starting on a separate page, with Arabic numerals corresponding to the illustrations.

When symbols, arrows, numbers, or letters are used to identify parts of the illustrations, each of them must be identified and explained in the legend. The internal scale should be explained and the method of staining in photomicrographs be identified.

### **Units of Measurement**

Measurements of length, height, weight, and volume should be reported in metric units, i.e., meter(m), gram(g), or liter(l) or their decimal multiples.

Milliliter or deciliter should be expressed as ml or dl.

Red and white blood cell counts are to be expressed as  $63 \times 10^6 / \text{mc l}$  and  $\times 10^6 / \text{mc}$  respectively. Temperatures should be given in degrees Celsius and blood pressures in millimeters of mercury (mmHg). All hematological and clinical chemistry measurements should be reported in the conventional system or in terms of the International System of Units (SI).

### **Abbreviations and symbols**

Only standard abbreviations are used in the text while avoiding abbreviations in the title and abstract.

The full term for which an abbreviation stands should precede its first use in the text unless it is a standard unit of measurement. Year, month, day, hour, minute and second should be abbreviated as yr, mon, d, h, mm, and s in tables respectively.

## References

1. Mother M, Schulz KF, Altman DG, for the CONSORT Group. The CONSORT statement Revised recommendations for improving the quality of reports of parallel group randomize Trials. *Lancet* 2001; 357: 1191-1194. (Also available from: URL: <http://www.consort-statement.org/>). Accessed June 28, 2002.
2. International Committee of Medical Journal Editors. Uniform Requirements for Manuscripts Submitted to Biomedical Journals. *Ann Intern Med* 1997;126:36-47. (Updated October 2001 version Available from: URL: <http://www.icmje.org/>). Accessed June 28,2002.
3. JAMA Instructions for Authors. Available from URL: <http://jama.ama-assn.org/>. Accessed June 28, 2002.
4. Hall GM. Structure of a scientific paper. In: Hall GM, ds. *How to write a paper*. London:BMJ Books, 2000.
5. 52nd WMA General Assembly. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Available from: URL: <http://www.wma.net/>. Accessed June 28,2002.

## Appendix 1:

### Declaration of Originality and Transfer of Copyright

*(Please download from Nigerian Association of Orthodontists (NAO) website <https://www.nao-ng.org/>)*

This form is to be submitted with the initial copies of the manuscript to: West African Journal of Orthodontics, Department of Child Dental Health, Obafemi Awolowo University Ile-Ife, Osun State. Nigeria Manuscript No. (If known):

The author(s) hereby affirms that the submitted manuscript entitled:

I/We certify that the manuscript represents valid work and that neither this manuscript nor one with substantially similar content under my/our authorship has been published or is being considered for publication elsewhere. For papers with more than I author, we agree to allow the corresponding author to serve as the primary correspondent with the editorial office, to review the edited typescript and proof.

I/We have seen and approved the submitted manuscript. All of us have participated sufficiently in the work to take public responsibility for the contents. All the authors have made substantial contributions to the intellectual content of the paper and fulfill at least 1 condition for each of the 3 categories of contributions: i.e., Category 1 (conception and design, acquisition of data, analysis and interpretation of data), Category 2 (drafting of the manuscript, critical revision of the manuscript for important intellectual content) and Category 3 (final approval of the version to be published).

I/We also certify that all my/our affiliations with or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript are completely disclosed on the title page of the manuscript. My/our right to examine, analyze, and publish the data is not infringed upon by any contractual agreement.

I/We certify that all persons who have made substantial contributions to the work reported in this manuscript (e.g., data collection, writing or editing assistance) but who do not fulfill the authorship criteria are named along with their specific contributions in an acknowledgment section in the manuscript. If an acknowledgment section is not included, no other persons have made substantial contributions to this manuscript.

I/We also certify that all persons named in the acknowledgment section have provided written permission to be named.

The author(s) undersigned hereby transfer(s), assign(s), or otherwise convey(s) all copyright ownership, including any and all rights incidental thereto, exclusively to the West African Journal of Orthodontics, in the event that such work is published in the West African Journal of Orthodontics.

Authors name(s) in order of appearance in the manuscript; signatures (date):

