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# 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

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## 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	CA vs	CA vs
				DM	WM1	WM2
				md	md	md
				(p-value)	(p-value)	(p-value)
7 to 8	11	7.90±0.49	8.20±0.51	-0.30(0.128)	0.51(0.022)*	-0.18(0.413)
9 to 10	12	9.67±0.59	9.23±0.69	0.44(0.107)	-0.19(0.577)	0.04(0.905)
11 to 12	8	11.73±0.65	10.08±0.86	1.65(0.001)**	0.30(0.502)	0.30(0.580)
13 to 14	5	14.01±0.59	12.71±0.88	1.30(0.025)*	0.77(0.151)	0.55(0.363)
15 to 16	3	15.86±0.77	15.57±0.75	0.29(0.670)	0.66(0.523)	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>0.01(0.964)</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

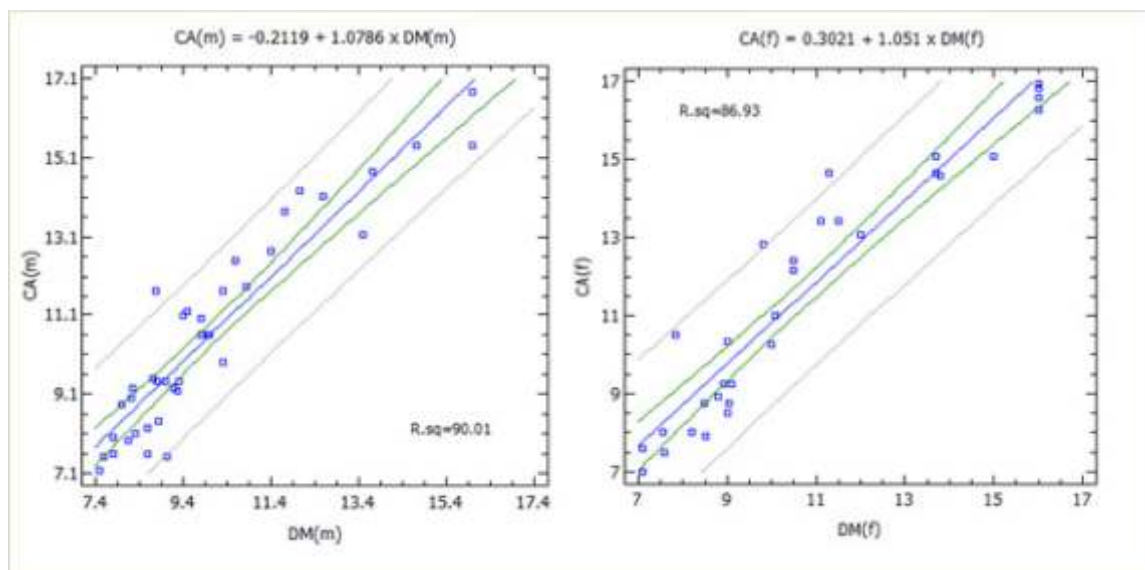
**Table 7B. Mean (S.D) and mean difference (md) between C.A and the estimated DAs using DM, WM1 and WM2 in males**

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>

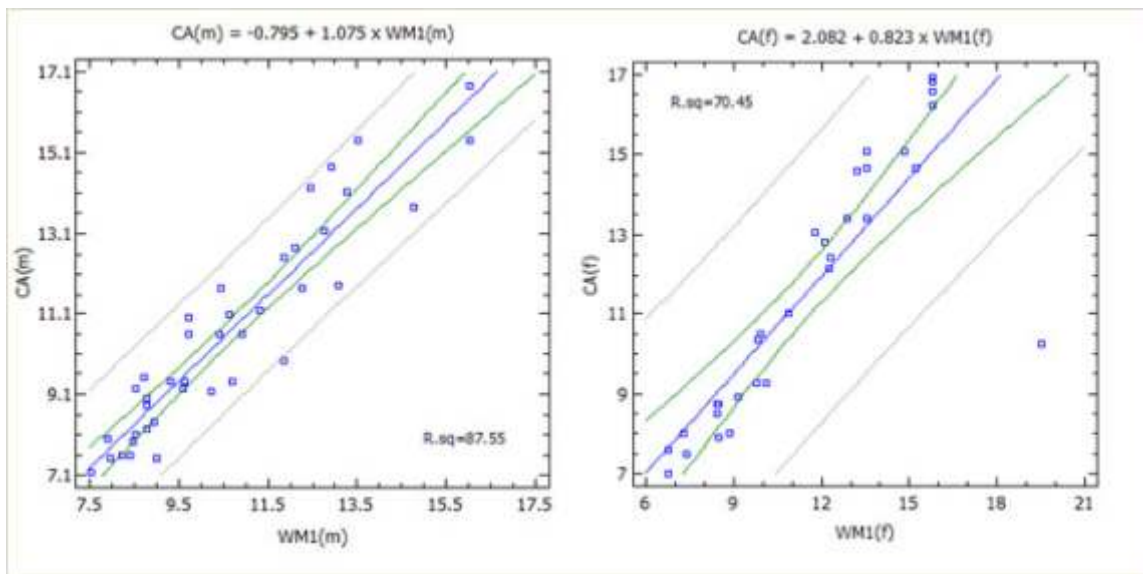
CA: Chronological Age, DA: Dental Age, DM: Demirjian Method, WM1: Willems I Method, WM2: Willems II Method  
 \*\*\*p-value <0.001, Very highly significant difference      \*p-value <0.05, Significant difference  
 \*\*p-value <0.01, Highly significant difference              p-value ≥0.05, Non-significant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

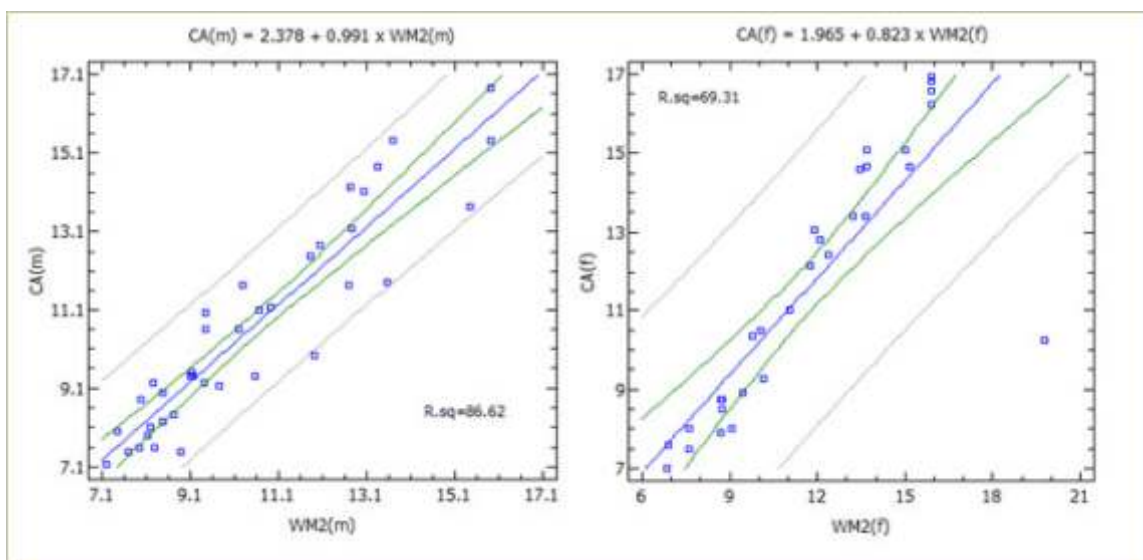
The correlations between the chronological age (CA) and the estimated dental age (DAs) using DM, WM1, and WM2 for males and females were presented in Figs. 1, 2, and 3 respectively. The scatter plot graph showed a strong positive correlation between the two measures. The R<sup>2</sup> values were 0.900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

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### Conflict of Interest

None declared

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# Overbite Depth Indicator (ODI) and Anteroposterior Dysplasia Indicator (APDI) Cephalometric Norms for an Adult Nigerian population.

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## Abstract

**Background:** Vertical and sagittal jaw relationships have been evaluated in the past using the Overbite Depth Indicator (ODI) and the Anteroposterior Dysplasia Indicator (APDI) measurements, respectively. These values have been studied in different populations, but there is a paucity of data among Nigerians. The aim of this study was to determine the mean ODI and APDI values in a young adult Nigerian population and to compare this with the values for Black American and Caucasian populations.

**Methods:** The cephalometric radiographs of 73 young adult Nigerians aged 18-25 years, with normal occlusion and no prior orthodontic treatment, were used. All radiographs were manually traced to determine the value of the ODI and APDI angles. The mean values for both angles were computed. Students' t-tests were used to assess for gender differences and to compare the mean ODI and APDI values between the Nigerian population studied, with African American and Caucasian populations, respectively.

**Results:** The mean age of the study participants was 21.67±2.3. The mean ODI and APDI angles recorded were 69.39° ± 7.2° and 82.51° ± 4.7°, respectively. There were no significant gender differences recorded for both angles.

**Conclusion:** Findings from this study showed the values for ODI/APDI were slightly similar in overall range to those of the African American population, even though the mean values were slightly lower in the Nigerian population.

**Keywords:** Overbite Depth Indicator, Anteroposterior Dysplasia Indicator, Cephalometric norms, Nigerians,

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## Introduction

Orthodontic treatment involves the correction of anomalies in the teeth and jaws. It requires comprehensive consideration of all the dental and skeletal features of an individual to arrive at a proper diagnosis. Therefore, successful orthodontic treatments rely largely on various standardized diagnostic measures to develop an objective assessment of the underlying aetiology of

malocclusion and to properly plan treatment. The cephalometric radiograph is still the most reliable diagnostic tool used in clinical diagnosis of discrepancies of the face and jaws<sup>1</sup>

Cephalometric radiographs have been found to provide a means of accurately evaluating the relationships of different parts of the face that best fits the description of the average facial form of ideal occlusion. Imaging is a standard aspect of a patient's clinical records in orthodontic diagnosis and treatment planning<sup>1</sup>. The ability to incorporate the various hard and soft tissue cephalometric values into treatment consideration has become increasingly important in recent years<sup>22</sup>

The measurement of vertical and sagittal skeletal relationships form an important aspect of cephalometric assessment in orthodontic diagnosis and treatment planning. In the past, vertical jaw

relationships were assessed with Downs mandibular plane angle (FMA), Y-axis, Steiner mandibular plane angle (SNMP), facial angle and several others.<sup>3</sup> The Frankfort plane was used as a reference plane and one of the problems regarding these analyses was related to difficulty in identifying the landmarks.<sup>3</sup> In order to overcome this deficiency and facilitate diagnosis, Kim,<sup>4</sup> studied cephalograms of 119 subjects with ideal occlusion and introduced the overbite depth indicator (ODI) to assess the skeletal relationship in the vertical plane. The ODI is the sum of two interplanar angles that showed the highest correlation with incisor overbite. It describes the skeletal trends towards open bite or deep bite.<sup>3</sup>

Indeed several parameters of orthodontic value have been defined to assess sagittal relationships. The ANB angle which was introduced by Riedel in 1952, the Wits appraisal and McNamara analysis have all been used to assess sagittal skeletal relationships in the past.<sup>5,6,7</sup> Studies show the differences measured by the ANB are not always indicative of the relationship of the apical base.<sup>8</sup> Indeed, the values of the ANB angle are affected by the steepness of the S-N plane, variation in the position of point A due to root position, exceptionally long or short mandible, and facial height.<sup>9</sup> Jacobson<sup>10</sup> also stated that errors could occur in the ANB measurement due to displacement of the nasion or rotation of the jaws which led to the development of Wits appraisal. Wits appraisal provided a simple method of measuring the severity of anteroposterior dysplasia of the jaw on the lateral cephalometric film, by drawing perpendicular lines from the A and B points to the functional occlusal plane.<sup>6,10</sup> However, this also posed some challenges, particularly in determining the functional occlusal plane in mixed dentition, in patients with anterior open bites, occlusal cants or missing teeth.<sup>11</sup> Kim and Vietas<sup>12</sup> developed the anteroposterior dysplasia indicator (APDI) after studying the cephalograms of 102 subjects with normal occlusion, and 874 subjects with different dental malocclusions based on Angle's classification. They described the APDI as the sum of three measurements: the facial angle, the A-B plane, and the palatal plane in relation to the Frankfort horizontal. More recently, the APDI was found to be geometrically equal to the angle formed by the A-B plane and the palatal plane.<sup>13</sup>

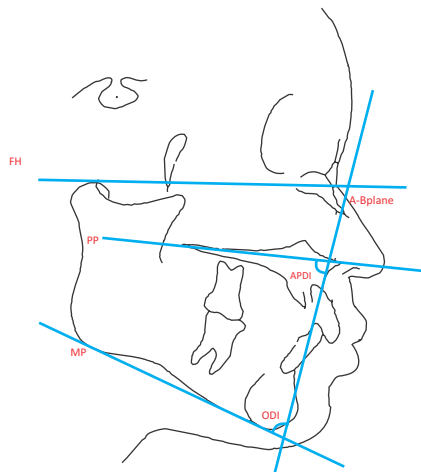
Different studies have shown that the ODI and APDI values vary in different populations.<sup>3,12,14,15</sup> <sup>16</sup>These studies reflect the ethnic variations for both measurements. Furthermore, the values are

particularly significant in the diagnosis and treatment planning of vertical and sagittal discrepancies. The paucity of data on these angles in the Nigerian population makes it a crucial area of research, as these values will be of significant benefit in orthodontic treatment planning for Nigerians. Thus, this study aimed to develop normative values for ODI and APDI in a young adult Nigerian population and to compare these values with established values for Caucasians and African Americans.

## Materials and Methods

This was a retrospective cross-sectional study carried out at the Orthodontic unit of the Child Dental Health Department of the Lagos University Teaching Hospital (LUTH), Nigeria. The radiographs for this study had previously been used to assess the soft tissue profile of undergraduate students at the University of Lagos.<sup>17,18</sup> The subjects were made up of second-year to final-year medical, dental, and pharmacy students of the College of Medicine, University of Lagos, Idi-araba, Lagos, Nigeria. The first step of the selection process involved clinical examinations and interviews to determine those who met the selection criteria: Nigerians with Nigerian grandparents; 18 to 25 years; symmetrical face and a harmonious facial profile, no previous orthodontic or prosthodontic treatment and no craniofacial deformities or history of trauma. Female subjects who were pregnant or likely to be pregnant were excluded from the study. The sample population consisted of 73 Nigerian adults (29 Males and 44 Females).

All the radiographs were hand-traced under a well-illuminated view box by two calibrated examiners (OA and OAK). Four planes and their landmark points were identified to measure the ODI and APDI variables. The AB plane (from point A to point B), the Mandibular plane (line from gonion to menton), the Frankfort Horizontal plane FH (a line from orbitale to porion), and the Palatal Plane PP (line from the anterior nasal spine to the posterior nasal spine) were traced (Figure 1). As previously described by Kim,<sup>4</sup> the ODI was defined as the sum of the angle formed by (1) the AB plane and the mandibular plane with the angle formed by the (2) palatal plane (PP) and Frankfort horizontal<sup>20</sup>. Subtraction of the angle formed by FH and PP was done from the ODI where PP sloped upwards and anteriorly in relation to the FH. On the other hand, the relative value of the PP-FH angle was added to ODI, where the Palatal Plane



**Figure 1:** Lateral cephalometric radiograph illustrating the planes used to determine the ODI and APDI variables. Abbreviations: A-B plane indicates A-point to B-point plane; APDI, Anteroposterior Dysplasia Indicator; FH, Frankfort horizontal plane; MP, mandibular plane; ODI, Overbite Depth Indicator; PP, palatal plane

sloped downwards and anteriorly to the Frankfort Plane. The APDI was defined as the angle formed by the AB plane and the Palatal Plane angle<sup>19</sup> (Figure 1).

To assess intra-examiner reliability, 5 radiographs were randomly selected and traced one week after. The concordance correlation coefficient was used to measure intra-observer reliabilities. Descriptive statistics included mean, median, standard deviation, and range values for ODI and APDI measurements. Student's t-test was used to assess the mean ODI and APDI values for gender differences. One-way analysis of variance and the Turkey tests were used to compare mean ODI and APDI values recorded in this study with those reported for African American and Caucasian populations.

**Results**

Reliability tests showed a positive correlation between the measurements recorded by both investigators who traced the cephalograms for the ODI and APDI measurements, with values of  $r=0.844$ ,  $p=0.002$  and  $r=0.903$ ,  $p=0.000$  recorded respectively for both measurements. A very high level of intra-examiner reliability was also recorded by the investigators for both measurements ( $r>0.8$ ).

The mean age of the respondents was  $21.67\pm 2.3$  years. The gender distribution was 60.3% (29) females and 39.7% (44) males. Table 1 shows the age distribution of the study participants.

The mean ODI values recorded for Nigerian adult males and females were  $68.9\pm 8.0$  and  $69.66 \pm 6.6^0$  respectively. There were no significant gender differences recorded. Furthermore, the mean APDI values recorded for male and female adults were  $82.91^0\pm 5.2^0$  and  $82.24^0\pm 4.0^0$  and no significant gender differences were reported. (Table 2)

When compared with the mean ODI in African Americans and Caucasians (Table 3), the mean ODI recorded in this study ( $69.39\pm 7.2$ ) was similar to that reported for African Americans<sup>16</sup>( $70.98^0$ ) but significantly lower than that reported for Caucasian populations ( $74.5^0$ )<sup>4</sup>. In addition, the mean APDI angle recorded in this study was significantly higher than that recorded in African Americans<sup>16</sup> ( $78.18$ ) and similar, although slightly higher than the mean value reported in Caucasians<sup>4</sup>.

**Table 1. Age and gender distribution of participants**

Age group (Years)	Frequency (n=73)	Percentage
18-20	23	31.5
21-22	25	34.2
23-24	14	19.2
>24≤25	11	15.1
Mean±SD	21.67±2.3	
Gender		
Male	29	39.7
Female	44	60.3

**Table 2. Mean comparison of ODI and APDI according to gender**

	Male	Female	t-value	p-value
OI	68.99±8.0	69.66±6.6	-0.388	0.699
APDI	82.91±5.2	82.24±4.5	0.592	0.55

**Table 3. Comparison of the mean values of ODI with Nigerian, African American, and Caucasian values.**

ODI Values comparison	Mean value (degrees)	Sample size	F value (p)
Current study	69.39 ±7.2	73	0.0000
Previous Nigerian study	66.85 ± 4.46	50	
African American Study	70.98 ± 5.8	160	
Caucasian Study	74.5±6.07	119	

One-way ANOVA and Post-Hoc Turkey tests: At 95% CI revealed the following:

Current study compared to previous Nigerian study<sup>20</sup> by Adediran *et al*: p=0.0996

Current study compared to African American study<sup>16</sup>: p=0.2858

Current study compared to Caucasian study<sup>4</sup>: (Kim, 1974) \*p=0.000

Previous Nigerian study<sup>20</sup> (Adediran *et al*) compared to African American study<sup>16</sup>: \*p=0.0002

Previous Nigerian study<sup>20</sup> (Adediran *et al*) compared to Caucasian study<sup>4</sup>: \*p=0.0000

African American Study compared with a previous Nigerian study<sup>20</sup> \*p=0.0000

\*p<0.05

**Table 4. Comparison of mean values of APDI with African American and Caucasian values.**

APDI Values comparison	Mean value (degrees)	Sample size	F value (p)
Current study	82.51±4.7	73	0.000
African American	78.18	160	
Caucasian	81.4±3.8	102	

One-way ANOVA and Post-Hoc Turkey tests at 95% CI

Current study compared to African American<sup>16</sup> \*p=0.0000

Current study compared to Caucasian study p=0.1976

African American<sup>16</sup> study compared to Caucasian study \*p=0.0000

## Discussion

ODI and APDI cephalometric variables have been studied in various populations.<sup>3,4,13,15,16,20</sup> The studies

carried out in these populations have validated the diagnostic efficiency of both variables. However, there is limited data on normative cephalometric

values or cephalometric analysis of Nigerian patients using both variables.

One of the few studies carried out to assess ODI values in a Nigerian population is the study by Adediran *et al.*<sup>20</sup> The mean value of the ODI value recorded in that study for a population with normal occlusion was  $66.85^0 \pm 4.46^0$  and this is closely related to the value recorded in our current study of  $69.39^0 \pm 7.20^0$ . This is underscored by the absence of a significant difference between the mean ODI values recorded in both studies. The findings from that study also indicated that the Nigerian population studied had a tendency towards a deep bite and that the ODI was able to sufficiently differentiate between patients with anterior open bites and normal controls. However, because a larger sample was used in the current study of 73 people compared to 50 people in the study by Adediran *et al.*,<sup>20</sup> it may be argued that the mean values obtained in this study may be more representative of the normative values of ODI for Nigerians.

An ODI value below the normative value indicates a greater tendency towards an open bite while values greater than the normative range reflect a tendency towards a skeletal deep bite.<sup>4</sup> This also explains the markedly lower mean ODI values recorded for patients with anterior open bites in the study by Adediran *et al.*<sup>20</sup> ( $63.13^0 \pm 6.71^0$ ), compared with the mean values recorded in this study. Thus, the findings from this study further demonstrate that the ODI value is a reliable cephalometric variable for the assessment of vertical discrepancies in Nigerians.

The ODI values obtained in this study were also closely related to the values that had been reported for African Americans by Obamiyi *et al.*<sup>16</sup> and this is most likely because of the racial similarities between both groups. The significantly lower values reported in our study compared with the normative values reported by Kim<sup>4</sup> for Caucasians highlight the fact that racial differences can affect the ODI value. Similar findings

have also been reported in other populations such as African Americans<sup>16</sup>, Latin Americans<sup>14</sup>, Koreans<sup>21</sup> and Iraqis<sup>22</sup>. Furthermore, the findings from this study show a greater tendency towards deep bite in the Nigerian population as was previously reported by Adediran *et al.*<sup>20</sup> This greater tendency towards a deep bite observed in the Nigerian population compared to Caucasians may also be associated with the bimaxillary proclination present in Nigerians, which has been previously reported.<sup>17,18,23</sup>

APDI has been reported to be an excellent parameter for the assessment of sagittal relationships.<sup>14</sup> This has also been validated by studies carried out in several populations.<sup>3,13-16,24</sup> The mean APDI values reported in this study were closely related and slightly higher than the original values reported by Kim and Veitas ( $81.4^0 \pm 3.8^0$ ). However, it is interesting to note that the mean value for APDI obtained in this study was significantly higher than that reported for African Americans by Obamiyi *et al.*<sup>16</sup> This may be because of the differences in the age groups of the study population of both studies. The study by Obamiyi *et al.*<sup>16</sup> was conducted on children aged 7-14 years, while our study was conducted on an adult population aged 18-25 years. The difference observed may be due to the significant changes that occur in the APDI with increasing age due to growth.<sup>25</sup> Thus, it is not surprising that the mean APDI values recorded in this study were also similar to the mean value reported by Caballero-Purizaga *et al.*<sup>14</sup> in a Latin American population with a mean age of 23.66 years. In addition to developing normative values for the APDI, there is a need for further studies in the Nigerian population to test the efficacy of the APDI in differentiating different sagittal relationships i.e Class I, Class II, and Class III skeletal relationships as has been done in other populations.<sup>3,14,15,22,24</sup>

The absence of significant gender differences for the mean ODI and APDI values observed in this study has also been reported in other studies.<sup>14,16</sup> The

findings from this study may also indicate that increasing age may affect mean APDI values more significantly than the ODI values, based on the comparisons made earlier between the mean APDI recorded in this study and that reported in other studies.

This study also has some limitations. The use of a larger sample size could have yielded more representative normative values for both variables. In addition, there is a need to test the efficacy of both variables in the cephalometric assessment of vertical and horizontal skeletal discrepancies in Nigerians using a larger study population. However, the findings from this study have provided a baseline for future studies and normative values that can be used for orthodontic treatment planning in the Nigerian population.

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## Conclusion

This study has established the normative values for ODI and APDI in a young adult Nigerian population as  $69.39^0 \pm 7.2^0$  and  $82.51^0 \pm 4.7^0$  respectively. The ODI value recorded in this study was closely related to that reported in an African American population but significantly less than that reported among Caucasians. However, the APDI values recorded in this study were slightly higher but similar to those reported in Caucasians and significantly higher than the value reported in African Americans. The differences in the APDI values in the populations studied were attributed to differences in the age groups of the study populations.

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# Prevalence and Perception of Maxillary Midline Diastema in Africa: A Scoping Review

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## Abstract

**Background:** Maxillary Midline Diastema (MMD) is a distinctive space or gap between the maxillary central incisors. It is also called “open teeth” or “gapped teeth. True midline diastema has been defined as the one without periodontal/periapical involvement and with the presence of all anterior teeth in the arch. It is most commonly applied to an open space between the upper incisors, that is, maxillary midline diastema being the most common of all the various types. Different people have different perceptions of MMD. The objective of the study was to synthesize the prevalence and perception of MMD in Africa.

**Method:** The authors conducted a review that included literature searches of four databases through March 2022: PubMed, Google Scholar, PMC, ResearchGate, and Cochrane library electronic databases on the prevalence and perception of MMD in Africa.

**Results:** In all, 32 articles were identified, 19 of these were considered for review and 13 met the eligibility criteria. The results showed MMD to be prevalent in Africa and found to be more in females than in males.

**Conclusion:** MMD is not uncommon in Africans and is perceived as a beauty sign among Nigerians and some African populations.

**Keywords:** Maxillary Midline Diastema, Prevalence, Perception, Africa, Scoping review.

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## Introduction

**M**axillary Midline Diastema (MMD) is a distinctive space or gap between the maxillary central incisors. It is also called “open teeth” or “gapped teeth”.<sup>1,2,3</sup> Maxillary Midline Diastema (MMD) is defined as a space greater than 0.5 mm between the proximal surfaces of two adjacent central incisors. True midline diastema has

been defined as the one without periodontal/periapical involvement and with the presence of all anterior teeth in the arch. It is most commonly applied to an open space between the upper incisors, making maxillary midline diastema the most common of all the various types.<sup>4,5</sup>

People's interest in the perception of the beauty of their teeth came to inception 2000 years ago, and ever since, attention has been placed on an individual's mouth and eyes when speaking in social environments.<sup>5,6</sup> The need for treatment of MMD is primarily due to psychological and aesthetic needs and not for functionality purposes.<sup>5</sup> MMD, a continuous space or gap between the maxillary central incisors, can be a normal growth feature which is characteristic of the primary and mixed dentition with the space closing normally by the time the maxillary canines are erupted. There are no exact rules governing what constitutes a beautiful occlusion of social acceptance. Also, the aesthetic

importance of maxillary anterior spacing varies both culturally and racially, therefore, the prevalence of MMD within a given population varies.

A naturally-occurring midline diastema may result from a wide range of aetiology including physiological, genetic, abnormal labial frenum, ectopic maxillary canines, dental alveolar disproportion, a missing tooth, peg-shaped lateral, proclination of the upper labial segment, unerupted midline supernumerary teeth, prominent frenum, tooth size or shape discrepancy, and mesiodistal angulations of incisors.<sup>5,7-9</sup>

Previous research reported varying responses regarding the perception of midline diastema, however, a reported increased frequency of maxillary midline diastema in Caucasian female models was considered an increase in acceptance of the maxillary midline diastema.<sup>5</sup> It was noted that the width of the diastema tends to affect its aesthetic acceptability.<sup>2,5,8,10</sup> Although MMD is appraised and seen as a sign of beauty among some African populations, there is a need to synthesize the perception and prevalence of MMD among the different populations in the continent of Africa. The

objective of this review is, therefore, to highlight the prevalence and the perception of Maxillary Midline Diastema in Africa.

### Materials and methods

The authors conducted a review that included literature searches of databases through March 2022 including PubMed, PMC, ResearchGate, Google Scholar and Cochrane library electronic databases. The articles included were focused on the prevalence and perception of MMD in Africa. Information not relevant to the scope of the study was not included.

### Results

In all, 32 articles were identified, of which 19 were considered for review and those that did prevalence studies and or perception of maxillary midline diastema were included in the review.

Thirteen articles met the eligibility criteria, out of which results of prevalence and perception of Maxillary Midline Diastema were synthesized.

**Table 1. Sources of Literature and Information included in this Review**

Serial No	Author	Country	Title	Type of Study	Sample size (N)	Prevalence
1. 2. 3.	Omosho G. et al. <sup>11</sup> (2009)	Nigeria	Midline Diastema amongst South-Western Nigerians.	Retrospective and Transcultural study	N=589	26.1%
4. 5. 6. 7.	Umanah et al. <sup>8</sup> (2015)	Nigeria	Prevalence of artificially created maxillary midline diastema and its complications in a selected Nigerian population.	Cross-sectional	N=141	28.4 %
8. 9. 10. 11. 12. 13.	Enabulele J.E.etal. <sup>5</sup> (2018)	Nigeria	Socio-cultural beliefs Regarding Midline Diastema among undergraduate students attending A Nigerian university.	Descriptive cross-sectional	N=400	29%
	Akinboboye O.B. et al. <sup>12</sup> (2018)	Nigeria	Perception of midline diastema in dental- and nondental-oriented individuals.	Analytic cross-sectional study	N=89	16.9%

Enabulele J.E. et al. <sup>13</sup> (2020)	Nigeria	How Attractive is the Maxillary Midline Diastema? Perception of Undergraduate Students Attending a Nigerian University	Cross-sectional	N= 333	34.8%
Rashid A. <sup>1</sup> (2021)	Egypt	Maxillary midline diastema among a group of Egyptian adult populations (prevalence and <i>aetiology</i> ).	Cross-sectional study	N=375	17.3%
Aikins E. <sup>18</sup> (2014)	Nigeria	Subjective Opinions of Dental Attractiveness and Orthodontic Treatment Need among Nigerian Adolescents.	Cross-Sectional study	N= 612	
Abdullah M. et al. <sup>3</sup> (2016)	Egypt	Revisiting the factors underlying Maxillary Midline Diastema.	Scientific study	N=100	13.6%
Ize Iyamu et al. <sup>19</sup> (2016)	Nigeria	Maxillary Midline Diastema in Nigerians: Beauty or Malocclusion.	Scientific Study	N= 203	
Mabiaku et al. <sup>14</sup> (2017)	Nigeria	Prevalence and Perception of Midline Diastema among Students of Institute of Health Information Management, University of Benin Teaching Hospital (UBTH), Benin City, Edo State, Nigeria	Descriptive cross-sectional study	N=100	28%
Athumani et al. <sup>15</sup> (2006)	Tanzania	Perception on diastema medialis (mwanya) among dental patients attending Muhimbili National Hospital.	Cross-sectional	N= 200	26%
Temisanren et al. <sup>16</sup> (2019)	Nigeria	Acceptability of midline diastema among dental technician students at the university college hospital, Ibadan.	Cross-sectional	N= 164	23.9%
Elfadel et al. <sup>17</sup> (2016)	Sudan	Prevalence and <i>aetiology</i> of midline diastema among Sudanese University students.	Cross-sectional	N=2200	7%

### Prevalence of MMD

According to a study carried out by Omotosho *et al*<sup>11</sup> in 2009 where a total of 589 questionnaires were administered at random to 271 female and 318 male students of the University of Ilorin, Nigeria to determine the incidence and heredity of midline diastema amongst the Yoruba-speaking southwest Nigerians, the incidence of diastema was found to be 26.1%.

The report is similar to the observations from the descriptive and cross-sectional study by Enabulele *et al*<sup>6</sup>, carried out among undergraduate students, at the University of Benin, Nigeria, to evaluate the prevalence and their sociocultural beliefs regarding MMD. They reported that, of the 400 students aged 16-46 years old, 29% of them had MMD. Later, another cross-sectional study of 333 undergraduate students of the sample population aged 16-30 years was done where data on socio-demographics, presence of midline diastema, self-assessment of the attractiveness of their smile and grading of a set of pictures with varying sizes of maxillary midline diastema (MMD) was analyzed and reported a prevalence of midline diastema of 34.8%.<sup>13</sup> The difference may be because of the sampling method and the smaller sample size.

Akinboboye *et al*<sup>12</sup> from their study comprised of diverse ethnic and social Nigerian groups, using a two-stage sampling method to select participants aged 20 to 49 years from the University of Lagos and the Lagos University Teaching Hospital, Lagos, Nigeria, found the prevalence of midline diastema to be 16.9%.

Mabiaku *et al*<sup>14</sup> reported a prevalence of 28% from their descriptive cross-sectional study on 100 undergraduates in Benin, Southern Nigeria, while Umanah *et al*<sup>8</sup> reported a prevalence of 28.4% from their cross-sectional study among patients attending a private dental clinic in Owerri, southern Nigeria.

Similarly, Athumani *et al*<sup>15</sup> reported a prevalence of 28% from their cross-sectional study of 200 adult patients aged 18 years and above attending the dental

clinic in Muhimbili National Hospital, Tanzania. Temisanre *et al*<sup>16</sup> reported a prevalence of 23.9% from their cross-sectional study on 164 dental technician students at the University College Hospital, Ibadan, Southwestern Nigeria.

However, Elfadel *et al*<sup>17</sup> reported a prevalence of 7% from their descriptive cross-sectional study on 2200 Sudanese University students.

Adel Rashid *et al*<sup>1</sup>, from their study to ascertain the prevalence and etiological factors responsible for maxillary midline diastema among a sample of Egyptian adult patients undergoing orthodontic treatment in orthodontic private clinics, using intraoral photography and radiographs, found that 17.3% of the studied patients had MMD, with no significant difference between the prevalence of MMD in both sexes ( $P=0.079$ ).

According to Umanah *et al*<sup>8</sup> on the prevalence of artificially created maxillary midline diastema (MMD) and its complications in a selected Nigerian population, the prevalence of artificially created MMD was 34.0%.

### Gender distribution of MMD

Omotosho *et al*<sup>11</sup> reported significant differences in gender distribution of MMD, the prevalence was found to be higher in females (33.9%) than males (19.5%),  $P$  value  $<0.05$ . Similarly, Mabiaku *et al*<sup>14</sup> reported from their study that MMD was higher in females (85.7%) than males. Furthermore, they reported that MMD was perceived to be more appealing to sight in females (50.6%) than in males (4.1%).<sup>11</sup> It was also observed that the majority of respondents (75.4%) attached some aesthetic significance to diastema, while 29.7% signified interest in artificial diastema.<sup>11</sup>

It was also reported that there were differences in the occurrence of diastema among various population groups, with close to two-thirds (64.9%) of the cases of diastema being inherited, with a higher likelihood in the males.<sup>11</sup>

### Aetiology of MMD

Abdullah *et al*<sup>3</sup> analysed the aetiological factors underlying the presence of maxillary midline diastema in a sample of orthodontic patients and suggested that diastema is a multifactorial clinical finding, with more than one predisposing aetiological reason. They recorded that there was an interrelationship between the familial pattern of midline diastema and microdontia, macroglossia, labial frenum, and alveolar cleft conform.<sup>3</sup> They however found that the effect of mesiodens and the upper lateral incisor (whether bilaterally missing, unerupted, or peg-shaped) was minimal.<sup>3</sup> This is contrary to findings by Adel Rashid<sup>1</sup> who recorded that the most common aetiological factors were congenitally missed laterals, highly attached frenum, generalized spaces, and flared incisors.

### Perception of MMD

A cross-sectional study on 612 randomly selected Nigerian adolescents from secondary schools to assess their opinions of dental aesthetics<sup>18</sup> revealed that the majority (78.1%) of the population expressed satisfaction with the arrangement of their teeth, and their perception of orthodontic treatment needs increased, as their satisfaction with the arrangement of their teeth decreased.

MMD was regarded as a sign of beauty and perceived to be an aesthetic attribute in females.<sup>5</sup> According to a study by Umanah *et al*<sup>8</sup>, a majority (69.5%) of their respondents desired MMD and 20.8% of those without it wanted it artificially created through

cosmetic dentistry. Reasons for artificial MMD include enhancement of personal beauty and aesthetics. Another study reported that 13.3% of their respondents believed that diastemas should be created artificially.<sup>19</sup> The artificially created maxillary midline diastema (MMD) was significantly more common in females (44.8%).<sup>8</sup> Enhancement of personal beauty and aesthetics was the major reason given by respondents for having it done,<sup>8</sup> while the commonest complication reported was tooth sensitivity.<sup>8</sup> While a study by Akinboboye *et al*.<sup>12</sup> concluded that their respondents perceived MMD to be an aesthetic trait provided that the width is within 2 to 3mm width, another study<sup>19</sup> found that the diastema width between 1- 6mm was regarded as a sign of beauty, but larger diastemas between 7-8mm were rated as unattractive and should be closed. Therefore, the less the width of the diastema the more acceptable it becomes.<sup>18</sup>

### Limitation

The results from the synthesis of this study were limited to Nigeria and some parts of Africa rather than a substantial population from other African countries. It is recommended that further studies should be carried out on a sample population from other African countries.

### Conclusion

Maxillary Midline Diastema (MMD) is not uncommon and has been found to be prevalent in Nigeria and some parts of the African population. MMD occurs more in females than males and is perceived as a beauty sign.

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# Management of Increased Overjet using the Contemporary Tip-Edge Plus Technique – A Case Report.

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## Abstract

**Background:** The aim of this case report was to present the successful orthodontic treatment of an adult patient with increased overjet, utilizing the contemporary Tip-Edge Plus technique.

**Methods:** The Tip-Edge plus appliance was employed with extractions of upper first and lower second premolars. The stages of treatment of the technique were followed. Once treatment was completed, retention was ensured with fixed retainers - a maxillary Begg retainer and a mandibular Hawley retainer.

**Results:** Treatment aims were achieved with a reduction in overjet and uprighting of upper and lower labial segments. The patient finished treatment with an aesthetically pleasing smile.

**Conclusions:** The Tip-Edge Plus appliance is an effective treatment modality in the management of patients with increased overjet.

**Keywords:** Increased overjet, Tip-edge Plus

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## Introduction

Increased overjet is a common feature of several malocclusions. An increased overjet is generally defined as one that is greater than 3mm. Several studies have described an increased prevalence of this condition in different populations.<sup>1,2</sup> Studies in some sub-Saharan African populations have estimated a prevalence of about 16%.<sup>3</sup>

Increased overjet poses significant adverse effects on the well-being of affected individuals. Negative effects on psychosocial well-being due to poor aesthetics<sup>4</sup> and an increased risk of trauma to the upper incisors have been described as major reasons for treatment.<sup>5</sup>

Several treatment modalities exist and are utilised based on the aetiology of the increased overjet. However, in patients where the cause of the condition is mainly dental, fixed orthodontic appliances with or without extractions are the treatments of choice.

While the use of the straight wire technique has been used successfully in the management of such conditions, some critics have pointed out some challenges with this technique, such as the imposition of bodily movement from the start of treatment which places a strain on anchorage. To remedy this, the Tip-

Edge bracket was invented by Dr P. C. Kesling in 1986, following an analysis of movements occurring during treatment with the Begg technique.<sup>6</sup> Kesling designed the Tip-Edge bracket to combine the benefits of differential tooth movement in the Begg technique and the control and torque delivery of pre-adjusted edgewise systems.<sup>7</sup> The Tip-edge system, therefore, offered quick correction of overjet and overbite and permitted the use of light forces that reduced strain on anchorage.

However, a major drawback to the use of the Tip-Edge system was the need to use auxiliary springs (Sidewinders) on all teeth to permit torque delivery at the latter stages of treatment. This problem was addressed with the development of the 'Plus' bracket which incorporated a deep tunnel through which a flexible NiTi archwire could be threaded to allow for tip and torque expression.<sup>8</sup>

The following clinical case describes the treatment of an adult patient with increased overjet using the Tip-Edge Plus technique.

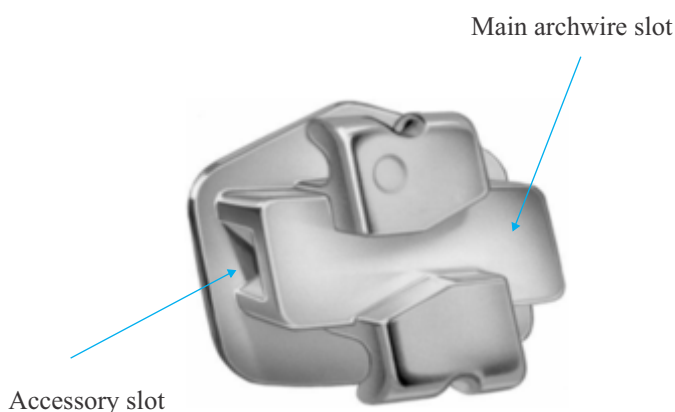
## Case Report

### Diagnosis

An 18-year 10-month-old female, G.D, presented at the Orthodontics and Paedodontics department of the University of Ghana Dental School, with the complaint of not liking the protruding nature of her front teeth.

Clinical assessment revealed proclined upper and lower incisors in a Class 1 incisor relation on a skeletal I base with average vertical dimensions, an overjet of 7mm, an overbite of 20% which was complete to dental hard tissue and teeth 35 and 37 in a scissor bite. There was mild crowding in the lower arch and mild spacing in the upper arch. The periodontium and temporomandibular joints were healthy.

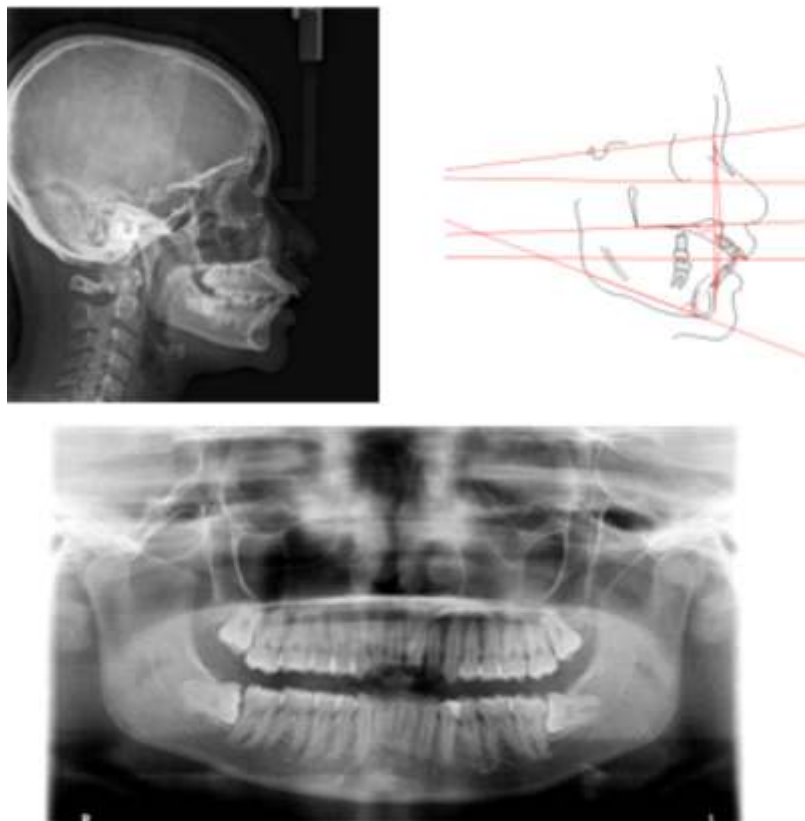
The panoramic radiograph revealed no bony or dental pathology. Crown root ratios of erupted teeth were within normal limits. Teeth 48 and 38 were horizontally impacted (surgically extracted before orthodontic treatment). A Cephalometric analysis confirmed clinical findings of a skeletal 1 base with an ANB of 4.1° and a Wits value of 3.1mm. An assessment of vertical relationships revealed that although the maxillary-mandibular planes angle (MMPA) was within normal limits, the Lower anterior facial height (LAFH) was reduced. The upper and lower incisors were proclined at a value of 138.2° and 109.8° respectively, and the resulting interincisal angle was subsequently reduced at 89.2°.



**Figure 1: The Tip-Edge Plus bracket.**



**Figure 2: Pretreatment facial and intraoral photographs of the patient.**



**Figure 3: Pretreatment panoramic radiograph, lateral cephalometric radiograph, and cephalometric tracing**



**Figure 4: Pretreatment study models**

**Table 1. Cephalometric summary of pretreatment and posttreatment results**

	Pretreatment	Posttreatment	Change during treatment
SNA(°)	87.3	91.3	+4
SNB(°)	83.3	86.9	+3.6
ANB(°)	4.1	4.4	+0.3
Wits appraisal (mm)			+1
MMPA(°)	22.8	21.3	-1.5
LAFH (%)			+1.1
Upper incisor to maxillary plane(°)	138.2	120.4	-17.8
Lower incisor to mandibular plane(°)			-1.5
Inter-incisal angle(°)	89.2	109.9	+20.7

### Treatment, Objectives, Progress, and Results

The patient was concerned with the appearance of her upper front teeth and was self-conscious about her appearance. She felt her upper front teeth were “sticking out and not well arranged”. Orthodontic treatment with fixed orthodontic appliances or clear aligners was offered as a treatment option. Fixed orthodontic treatment utilising the tip-edge plus appliance was selected as it affords early correction of proclined incisors and reduction in overjet which were her major concerns.

The orthodontic treatment objectives were to reduce the proclination of the upper and lower incisors, reduce overjet, relieve lower arch crowding, correct scissor bite of teeth 35 and 37, and close all residual spaces.

Treatment commenced with the extraction of the impacted lower third molars. Additionally, the upper first premolars and lower second molars were extracted. The upper and lower labial segments (incisors and canines) were then bonded with Tip-edge Plus® brackets and the upper and lower first

molars were fitted with bands that had triple and double tubes respectively.

Stage I of treatment commenced with the use of 0.016" Australian special plus archwires with circle loops placed between lateral incisors and canines in the upper and lower arches. Tip-back bends were placed 2mm mesial to all molars and the patient was asked to use 2.5 oz 5/16, and later 3.0oz 5/16 Class II elastics (from upper circle loops to lower molar hooks) bilaterally. Three (3) months later, the overjet and overbite had reduced significantly to 1mm each. The remaining brackets (14, 24, 35, 45) were then bonded. The upper premolar brackets (right and left) were swapped to permit space closure by mesial tipping of the posterior segments as well as distal tipping of the anterior segments.

Stage II followed 5 months later. Stainless steel (SS) archwires (0.020") with a curve of Spee in the upper arch and a reverse curve of Spee in the lower arch were fitted. Space closure was accomplished with E-links from molar hooks to circle loops positioned between lateral incisors and canines.

Two months later, all spaces were closed.

Treatment continued with Stage III and focused on root uprighting and torque expression. The 0.0215"x0.028" SS archwires were fitted in both upper and lower arches with 0.014" NiTi archwires threaded through the deep tunnels of the brackets. After 12 months (treatment was interrupted for 6 months due to the Covid-19 pandemic) the appliances were removed and upper and lower fixed lingual retainers were delivered. These were supplemented with an upper Begg wraparound retainer and a lower Hawley retainer.

Final records showed that the orthodontic treatment had accomplished the initial objectives. The inclination of the upper and lower incisors had been normalized and the overjet had been reduced to 2mm. Lower arch crowding had been relieved, and all spaces were closed. In comparison to the initial analysis, the final cephalometric analysis showed improvement in the upper incisor inclination (120.4°), lower incisor inclination (108.3°) and interincisal angle (109.9°). Overall, the patient's aesthetics were improved, and she was pleased with the treatment results.



**Figure 5. Intraoral photographs showing the three stages of treatment.**

## Discussion

Several options exist for the management of increased overjet and vary from removable orthodontic appliances with active labial bows, functional appliances, clear aligners and fixed orthodontic appliances. The option selected usually depends on the aetiology of the malocclusion as well as the familiarity of the orthodontist with a particular treatment method.

The Tip-Edge Plus bracket incorporates components from the Begg technique and therefore aims to utilize light forces as well as tipping the teeth at the beginning of treatment to allow rapid correction of overbite and overjet, and reduce the strain on anchorage, especially in the initial stages of treatment.<sup>9</sup> Aspects of the pre-adjusted edgewise technique are also incorporated in the Tip-Edge technique and, therefore, pre-determined tip and torque expression are permitted with this technique.<sup>8,10</sup>

Treatment with the Tip-Edge appliance generally follows three stages.<sup>8,9</sup> Stage I focuses on the anterior segments, aligning the teeth and closing all incisor spacing. Elimination of overjets, reverse overjets, increased overbites or anterior open bites are also

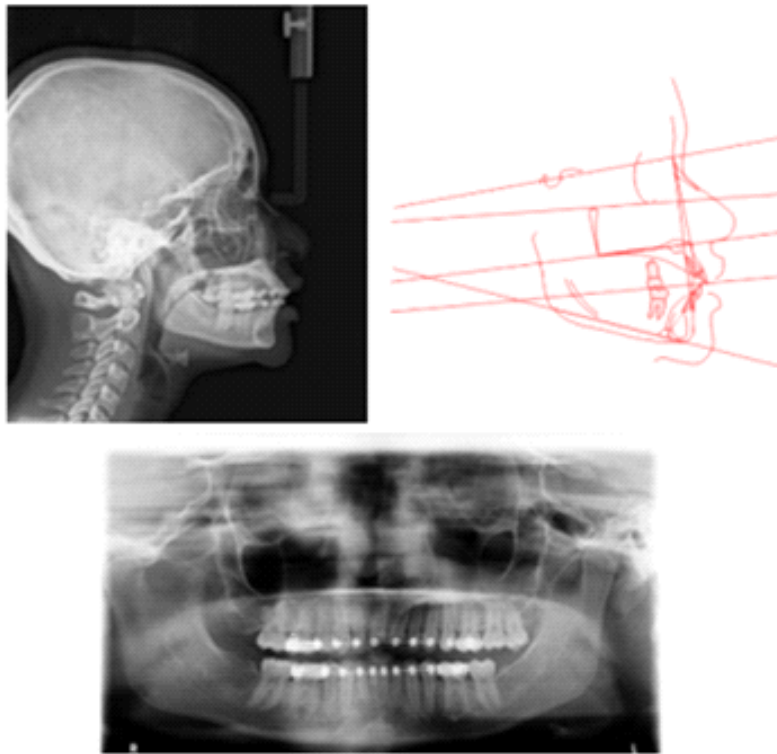
performed at this stage. The 0.016" high tensile stainless steel archwires are commonly used at this stage and typically stage I is completed in 6 to 9 months.

In stage II, all residual spaces are closed. It is typically brief (3 to 4 months) and the archwire usually employed is a 0.020" high tensile stainless steel archwire.

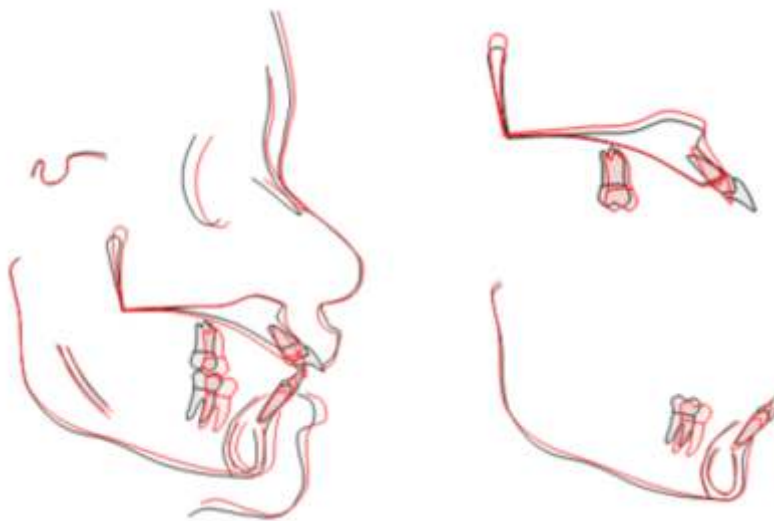
In stage III, the roots are uprighted and teeth are tipped and torqued to their preadjusted values. In this stage, the ease of use of the 'Plus' bracket is evident as a flexible NiTi archwire is threaded through the deep tunnels of the brackets with a full-thickness stainless steel archwire in the main bracket slot, as compared to the Tip-Edge Rx-1 brackets which utilise auxiliary Sidewinder springs on each tooth. The estimated duration of this stage for most treatments is 9 months. The advantages of the Tip-Edge system were readily evident in this case report. A reduction of overjet and overbite occurred rapidly, thus addressing the patient's major complaints at an early stage of treatment. Also, the use of light forces permitted very little anchorage loss, especially in the upper arch and allowed for the achievement of all treatment aims.



**Figure 6. Posttreatment facial and intraoral photographs.**



**Figure 7: Posttreatment lateral cephalometric radiograph and cephalometric tracing, and near-end panoramic radiograph**



**Figure 8: Initial (black) and final (red) cephalometric tracings, superimposed on the anterior cranial base (left), the stable skeletal structures of the maxilla (upper right), and the mandible (lower right).**

### Conclusion

Increased overjet is a common presentation in most malocclusions and several treatment options are available for its resolution. The Tip-Edge Plus technique, as demonstrated in this case report, presents another treatment modality which could prove useful in the armamentarium of orthodontists in the management of increased overjet.

### Acknowledgements

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# A Case of Bilateral Cleft of the Lip Alveolus and Palate treated with Presurgical Infant Orthopaedics using Clear Aligners

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## Abstract

### Abstract

A case report on presurgical infant orthopaedic management of a 1-day-old male patient with a bilateral cleft of the lip and palate, widely separated lip segments, rotated premaxilla, significantly increased alar base width, flattened nasal tip and a severely deficient columella using clear aligners.

Treatment objectives were to reduce the size of the cleft defect, lengthen the columella, improve nasolabial aesthetics and improve the outcome of surgical repair.

After a thorough patient assessment, presurgical infant orthopaedic treatment using the NAM aligner system incorporating nasal hooks and lip taping was planned. The treatment was carried out over a period of 12 weeks, with nasal moulding initiated after six weeks of aligners therapy using a nasal hook in conjunction with the NAM aligner.

After 12 weeks of presurgical infant orthopaedic treatment, the size of the cleft defect was significantly reduced, nasolabial aesthetics was improved and a significant increase in the columella length was achieved.

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## Introduction

Presurgical infant orthopaedics (PSIO) was introduced in the early 1900s with the primary objective of correcting the malpositioned alveolus before primary surgery in patients born with cleft lip and palate.<sup>1,2</sup> The concept of nasoalveolar moulding began to gain popularity in the 1950s, this was validated by the findings of Matsuo who reported that the nasal cartilage could be

moulded, due to increased lack of elasticity from increased levels of maternal oestrogen, if treatment is initiated within 6 weeks of life.<sup>3,4</sup>

Different techniques of presurgical infant orthopaedics have been recorded. These include alveolar moulding, lip strap, nasoalveolar moulding (NAM), and lip adhesion.<sup>5,6</sup> The NAM appliance consists of two components: an intraoral moulding plate and the nasal component, to align and approximate the alveolus as well as mould the distorted nasal cartilage concurrently.<sup>1,5</sup> Moulding can be achieved using active appliances that move the separate alveolar processes into position by applying active forces on them, or by a passive appliance which allow the passive growth of alveolar processes as planned by the clinician.<sup>5</sup> Grayson<sup>7</sup> introduced the passive NAM technique, describing it as one that involved passive moulding while simultaneously repositioning the deformed nasal cartilages and alveolar processes as well as the lengthening of the

deficient columella. This technique has been subjected to modifications aimed at improving infant and caregiver comfort as well as treatment outcomes.<sup>8-10</sup>

The use of clear aligners for orthodontic tooth movement was introduced in 1997 by Align Technology (Santa Clara, California), and their use has been increasing, mostly in adult patients.<sup>11</sup> In 2019, Batra *et al*<sup>12</sup> reported the use of clear aligners with nasal stents for presurgical infant orthopaedics which yielded promising results while increasing the comfort and convenience of the patients. They, however, reported that the use of clear aligners was at an additional cost when compared with other PSIO techniques. This case report demonstrates the treatment of a case of bilateral cleft of the lip, palate, and alveolus, with presurgical infant orthopaedics, using clear aligners.

### Presenting complaint

A day-old male patient, weight 2.90kg presented at the orthodontic clinic of the Department of Child Dental Health, Lagos State University Teaching Hospital, Lagos (LASUTH), with the chief complaint of abnormal lip and hole in the mouth, made by the parents.

### Medical, Family and Social History

Pregnancy history revealed that the mother was treated for malaria around 16 weeks of gestation. He was the last of 4 children. The father was a 36-year-old laundry man, while the mother was a 31-year-old housewife. There was no positive history of cleft among the nuclear and extended families, and neither of the parents smoked or consumed alcohol.

### Diagnosis

Examination showed bilateral cleft of the lips, palate and alveolus. The premaxilla was rotated, a cleft gap of 15.4 mm at lip level and 8 mm at the alveolar ridge level was observed on the right and a cleft gap of 13.2 mm at lip level and 5.9 mm at the alveolar ridge level was observed on the left. The ala and columella of the nose were collapsed. A total nostril width of 41 mm and a nostril height of 2 mm were recorded. All linear measurements were performed on clinical photographs (Figure 1) incorporating a millimeter scale to aid image calibration and prevent magnification errors using Adobe Photoshop 2020 v21.0.2.57 (Adobe Inc, San Jose, California).



**Figure 1:** Pretreatment extra oral and intra-oral photographs

## Treatment Objectives

The treatment objectives were:

1. To reduce the size of the cleft defect.
2. To improve the nasolabial aesthetics by approximate bilateral lip tissues, reduce the width of the nasal tip, improved nasal tip projection, and reduce nasal alar base width.
3. To lengthen the columella.
4. To align and approximate the intraoral alveolar cleft segments.
5. To improve the outcome of surgical repair of the cleft defect.

## Treatment alternatives

Four alternatives were presented to the parents;

1. Extraoral lip taping to reduce the size of the cleft defect. The intraoral alveolar cleft defect will not be aligned and approximated, neither will nasolabial aesthetics be improved.
2. Extraoral lip taping combined with nasal stents to reduce the size of the cleft defect and lengthen the columella. The limitation was that the intraoral alveolar cleft segments will not be aligned nor approximated.
3. Presurgical infant orthopaedics using acrylic NAM appliance to reduce the size of the cleft defect, improve nasolabial aesthetics and align and approximate alveolar cleft defects. The disadvantages are the multiple visits required for laboratory trimming of the appliance with treatment progression, the bulky size of the acrylic baseplate plate, and the risk of adverse reactions to the acrylic plate.
4. Presurgical infant orthopaedics using NAM aligner system incorporating nasal stents and lip taping to reduce the size of the cleft defect, improve nasolabial aesthetics, and align and approximate alveolar cleft defects. This option eliminates the multiple visits for laboratory trimming, and is more comfortable for the infant without the risk of adverse reactions to

acrylic. However, the limitation is in the cost of the aligners.

After a review of the risks and benefits of the options, the parents chose the more convenient method which was the fourth alternative based on the advantages of being more comfortable for the infant and easier on the parents.

## Appliance fabrication

### Impression Taking

An initial impression was taken with rubber-based impression material (Imprisil, Pyrax, India) using an acrylic stock tray (Figure 2(A)) with the help of a clinical assistant. The impression was taken in the orthodontic clinic, LASUTH. The infant was positioned inverted on the mother's lap and stabilized gently with the clinical assistant's hand. The heavy-bodied material was placed on the acrylic stock tray covered with a separator and the impression tray was seated in the infant's mouth to set according to the manufacturer's instructions. The impression was withdrawn and the infant's oral cavity was examined for the presence of residual impression materials. Thereafter, the separator was removed and the light body mix was syringed over the heavy-bodied impression and gently inserted into the infant's mouth and allowed to set according to the manufacturer's instructions. The set impression was withdrawn and the infant's mouth was suctioned to ensure no left-over impression material. The infant was observed to have cried throughout the process and was checked continuously for any signs of distress.

A thermoplastic special tray was fabricated from the initial impression and used to record the secondary impression (Figure 2(B)) using a rubber-based impression material (Imprisil, Pyrax, India) and the putty, followed by the light body mix in the orthodontic clinic, LASUTH.



**Figure 2:** Photographs of rubber-based impressions. (A: Initial impression taken with an acrylic stock tray; B: Secondary impression taken with a thermoplastic special tray)

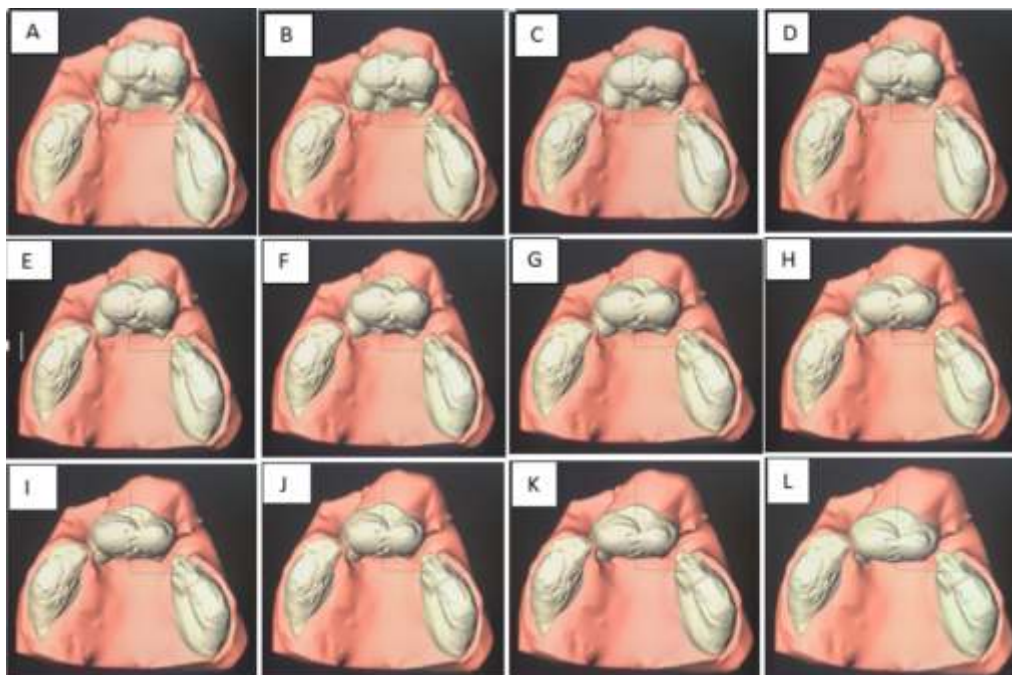
**Aligners' Fabrication**

A three-dimensional (3-D) model of the maxilla was made by laser-scanning the plaster model poured from the impression (Desktop Laser Scanner, Ortho Insight 3D®, TN, USA).

Using Ortho Insight 3-D software, a virtual set-up was made from the model separating the major and minor cleft segments. The number of stages required

to gradually mold the segments was determined based on the amount of movement desired to produce the desired results, without exceeding 1mm per stage (Figure 3).

The set-up was exported in STL file format to a 3D printer (Sprintray Pro 3D printer, CA, USA) for manufacturing, using the Die and Model 2 Gray resin (Sprintray, CA, USA).



**Figure 3:** Photographs showing 3-D models of the maxilla (A - model for aligner 0; B - model for aligner 1; C - model for aligner 2; D - model for aligner 3; E - model for aligner 4; F - model for aligner 5; G - model for aligner 6; H - model for aligner 7; I - model for aligner 8; J - model for aligner 9; K - model for aligner 10; L - model for aligner 11)

### Treatment Progress

Presurgical infant orthopaedics treatment began on the 10<sup>th</sup> of June, 2021 with the insertion of NAM aligner 0 (Figure 4). The aligners were retained naturally and retention was enhanced with denture adhesive (Fixodent, Procter and Gamble, OH, USA). On the same day, extra oral lip taping (Steri strip™, 3M Health care, MN, USA) was done and hydrocolloid dressing (DuoDERM\*, ConvaTec, United Kingdom) to protect the infant's skin from irritation (Figure 4). Parents were taught lip taping and tapes were changed 2-4 times a day after feeding or whenever the tapes peeled off, to ensure continuous orthopaedic force. The parents were also trained to insert, remove, and clean the aligners. They were also instructed to keep the aligner in the mouth throughout the day and night including during feeding and to clean the aligner twice daily with a soft toothbrush and gently wipe the oral cavity with cotton wool and lukewarm water. Aligners were changed weekly in incremental steps. The patient was recalled every two weeks.



**Figure 4:** Extraoral photographs showing aligner and extraoral lip taping.

After six weeks of aligners therapy, nasal moulding was initiated using a nasal hook along with the NAM aligner (Figure 5). Nasal moulding of the cartilage commenced using a stent in the form of an acrylic hook in each nostril taped to the forehead with hydrocolloid dressing protection over the skin. The

magnitude of the force was determined based on whether the nose tip turned white, if not, the force was increased. The tape connecting the nasal hook and the forehead was changed daily to make sure that the orthopaedic force was strong enough to elevate the nasal tip.



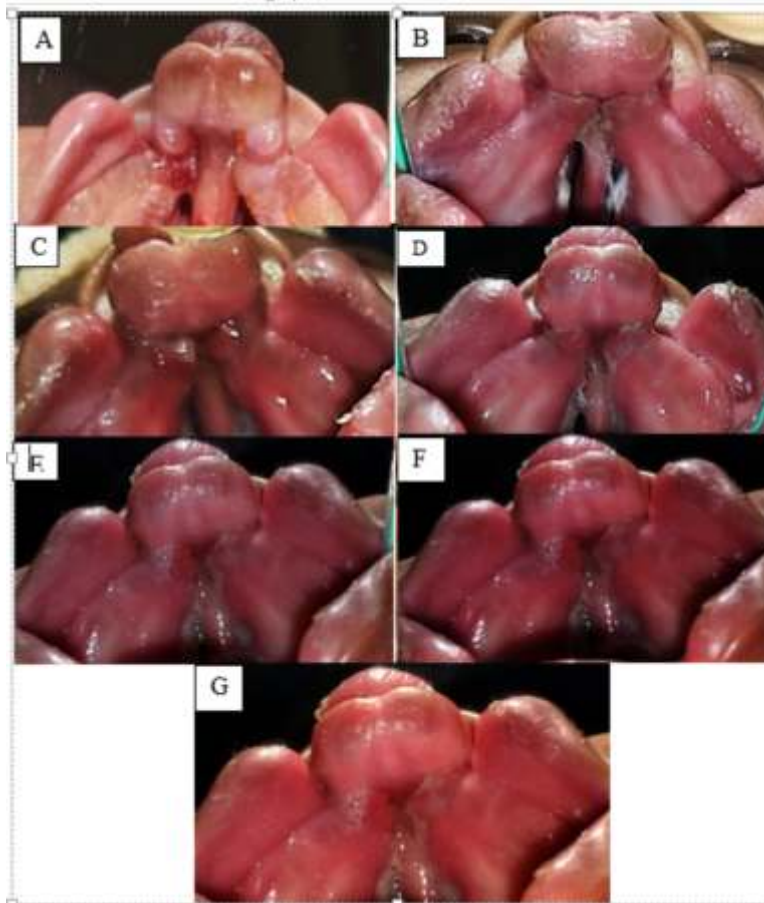
**Figure 5:** Patient at six weeks, showing commencement of the use of nasal hooks

### Treatment results

The treatment was completed over a period of 12 weeks (3 months). Figure 6 shows treatment progress for the course of the treatment.

The size of the cleft defect was significantly reduced, the nasolabial aesthetics was improved, alignment and approximation of the intraoral alveolar cleft segments were achieved and a significant increase in the columella length was achieved, (Figure 7).

The post-treatment linear measurements are shown in Table 2. Linear measurements were performed on clinical photographs incorporating a millimetre scale using Adobe Photoshop 2020 v21.0.2.57 (Adobe Inc, San Jose, California) to aid image calibration and prevent magnification errors. The soft tissue cleft gap at the lip level was reduced by 9.3mm on the right and 7.9mm on the left. At the alveolar level, there was a 6.7mm reduction in cleft defect achieved on the right and a 4.5mm reduction on the left. The total nostril width was reduced by 10mm, the nostril height increased by 3.6mm and the severely deficient columella was increased to 3.1mm.



**Figure 6:** Intraoral photographs showing treatment progress. (A - pre-treatment intraoral photograph before insertion of aligner 0; B - after insertion of aligner 1; C - after insertion of aligner 3; D - after insertion of aligner 5; E - after insertion of aligner 7; F - after insertion of aligner 9; G - post-treatment intraoral photograph after aligner 11)



**Figure 7:** Post treatment extraoral and intraoral photographs

**Table 1. Pretreatment and posttreatment linear measurements**

Parameters (mm)			Pre treatment	Post treatment
<b>Soft tissue cleft gap</b>	Lip level	Right	15.4	6.1
		Left	13.2	5.3
	Alveolar level	Right	8.0	1.3
		Left	5.9	1.4
<b>Total nostril width</b>			41.0	31.0
<b>Nostril height</b>			2.0	5.6
<b>Columella length</b>			Severely deficient	3.1

## Discussion

Presurgical infant orthopedics creates the foundation for good treatment outcome of primary lip and nasal surgery. This case shows a good treatment outcome of presurgical infant orthopedics which was achieved with NAM aligners along with nasal hooks. The success may be attributed to three factors, namely; proper patient selection – a day old infant,<sup>3,4</sup> comfort of the NAM aligners<sup>12</sup> and caregivers' comfort.<sup>12</sup>

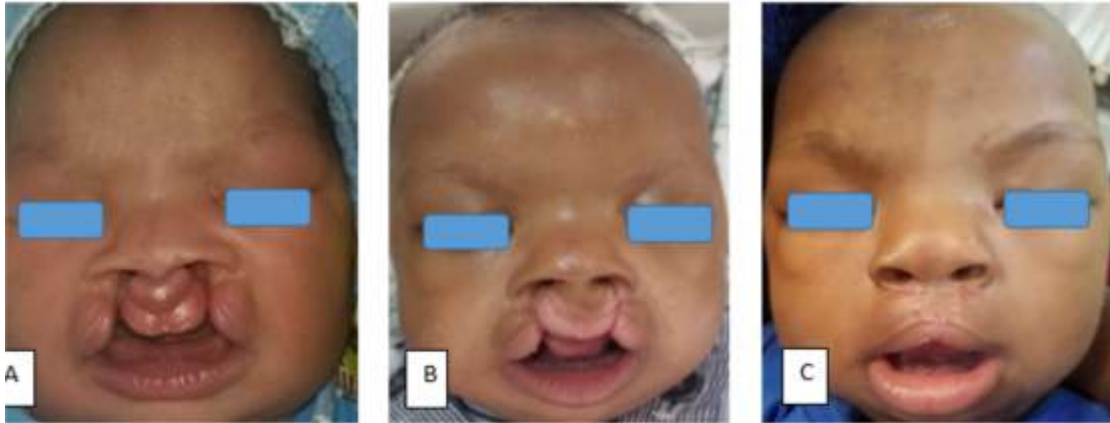
Matsuo<sup>3,4</sup> recorded that presurgical infant orthopedics is more effective when commenced early, immediately after birth. It was suggested that the high level of estrogen during childbirth with the increased levels of hyaluronic acid, prevents intercellular cartilage matrix linkage makes the facial cartilages soft and lacking elasticity allowing for the molding.<sup>3,4</sup> The infant in this present case presented few hours after birth, this can be attributed to the successful treatment outcome.

The use of NAM aligners also simplifies the molding process eliminating the laboratory procedures in the Grayson technique thus making the process more convenient for the patient and the caregiver by eliminating multiple visits. In addition, the unwanted effects<sup>12</sup> associated with acrylic plate—such as pressure ulcers and soft tissues laceration are eliminated, in addition to the light weight of the

aligners may have contributed to increased tolerance of the appliance by the infant.<sup>12</sup>

Taking into consideration that the NAM aligners are removable appliances, compliance of the caregivers in the use of the aligners as well as the nasal stents and lip taping could also have contributed to the treatment outcome. Nasal moulding was commenced after six weeks of aligners therapy with the NAM aligners according to the principles of Grayson and Maull,<sup>13</sup> which states that with alveolar gap reduction, there is improvement of alignment of the base of the nose and the adjacent lip segment. This leads to laxity of the previously tense alar rim and allow for the nasal molding to take place more efficiently.

After 12 weeks of presurgical infant orthopaedic treatment using NAM aligners, nasal hooks and lip taping; the size of the cleft defect was significantly reduced, the nasolabial aesthetics was improved, and alignment and approximation of the intraoral alveolar cleft segments were achieved as well as significant increase in the columella length (Figure 7). This is in agreement with most authors who reported that PSIO with NAM results in alignment and approximation of tissues, improved nasolabial aesthetics, increase in columella length, significantly better surgical outcome compared with patients who do not undergo NAM therapy.<sup>1,5</sup>



**Figure 8:** Extraoral photographs A: before PSIO, B: after PSIO, C: post-surgery.

## Conclusion

This case has demonstrated the successful treatment of a case of bilateral cleft of the lip, palate and alveolus with presurgical infant orthopaedics using clear aligners.

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