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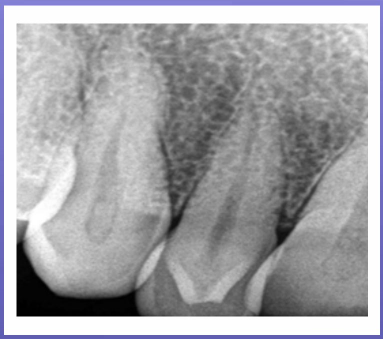

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Editorial

Malocclusion significantly affects individuals' quality of life, impacting nutrition, speech, and psychosocial well-being. In low- and middle-income countries (LMICs), access to orthodontic care is limited—not because of a lack of need, but due to the chronic shortage of trained specialists. At the heart of this problem lies a fragile training infrastructure plagued by underfunding, inconsistent standards, and the relentless loss of talent to more developed nations.

Dental schools in many LMICs operate under tight financial constraints, often relying on outdated equipment and lacking essential clinical tools like imaging systems or modern orthodontic materials. Students graduate with minimal exposure to contemporary practices, which undermines their confidence and readiness for clinical work. Meanwhile, the lack of simulation technologies and hands-on models limits the development of essential skills during training.

This is further complicated by restricted internet access and the high cost of digital resources, which keep many faculty and students cut off from global developments in orthodontics. In an age where digital tools drive education and research, this technological divide deepens inequality and slows the pace of local progress.

Then there's the ongoing loss of human capital. Orthodontists trained in LMICs often leave in search of better working conditions, research opportunities, and financial security abroad. This migration is a major setback, draining already limited health systems of expertise, leadership, and mentorship. In effect, LMICs are subsidizing the specialist workforce of wealthier nations.

Curriculum design also poses challenges. In many institutions, orthodontic training includes excessive rotations outside of the specialty and lacks emphasis on critical thinking, research, and innovation. This creates a generation of clinicians who are technically competent but disconnected from the evidence base and unprepared to contribute to the evolution of care that meets local needs.

To move forward, orthodontic education in LMICs must become more intentional and adaptive. Curricula should be aligned with population needs, focusing on high-impact clinical skills, ethical care, and region-specific challenges. Affordable simulation tools and open-access digital learning can help bridge resource gaps. Equally important is faculty development—training the trainers—to foster leadership, mentorship, and academic growth within local institutions.

National dental associations must also play a more active role in setting training standards, supporting quality assurance, and advocating for investment in dental education. Governments, in turn, must create an enabling environment for professionals to stay and thrive, through better infrastructure, fair compensation, and research funding. International partners can support these efforts by promoting equitable collaboration and respecting ethical recruitment guidelines.

Improving orthodontic training in LMICs is not a luxury—it is a necessity. These countries deserve self-sustaining systems that produce skilled, motivated professionals equipped to meet the needs of their communities. With targeted investment, strong leadership, and strategic partnerships, that future is within reach.

Prof O.O. Sanu
Associate Editor

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The Relationship Between Skeletal Malocclusions, Fingerprints and Blood Group in Patients Attending an Orthodontic Clinic in Benin City

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Abstract

Background: Documented evidence suggests a relationship between dermatoglyphic patterns, blood group system, and the development of malocclusion. The wide variations observed have been suggested to be due to genetic and environmental influences. More research to ascertain the relationship between malocclusion with fingerprints and blood group in Nigerians is essential. The objective of the study was to assess the relationship between skeletal malocclusion with fingerprints and blood group in a Nigerian population.

Methods: A total of 205 patients, aged 13-40 years, attending the Orthodontic clinic of the University of Benin Teaching Hospital, Benin City who met the inclusion criteria were selected. Their sagittal and vertical jaw relationships were determined by tracing the patients' lateral cephalometric radiograph. Fingerprints of both hands were taken using a Bio scanner, while blood samples were collected to determine their ABO blood group.

Results: More than half of the patients (55.6%) had skeletal pattern 1 malocclusion. The fingerprint pattern showed that the ulnar loop had the highest frequency across all types of skeletal malocclusion (61.8%), followed by whorl (24.5%), arch (10.2%), and radial loop (3.5 %). The fingerprint patterns of the left thumb, index finger, fifth finger, and right thumb had significant relationship with the different classes of skeletal malocclusion (p<005)

Conclusion: There was a relationship between dermatoglyphic pattern and skeletal malocclusion. No significant relationship was found between skeletal malocclusion and blood group. Dermatoglyphic patterns of some digits show predictive values when compared to others.

Key words: Fingerprint, blood group, malocclusion, skeletal.

ORIGINAL ARTICLE

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Introduction

Malocclusion may be defined as a significant deviation from what is defined as normal or ideal occlusion.[1-3] It is one of the common oral conditions that is often reported in literature.[1] The aetiology of malocclusion is multi-factorial, ranging from genetic factors to environmental factors and these factors influence the development of the jaws.[4] Skeletal malocclusion occurs as a result of the distortion of the normal maxillary and/or mandibular growth during embryonic development.[4] At present, malocclusions are ranked third in the order of priorities among the problems of dental public health worldwide.[5] It is estimated that approximately 1.2 million people in the United States have an extreme dentoskeletal anomaly.[6] Approximately 60% have a class II malocclusion, 25% have a class III malocclusion, and around 15% have a mix of dentoskeletal irregularities.[7] Class III malocclusion is thought to be one of the most complex as well as challenging orthodontic problems to deal with. The prevalence of class III malocclusion in North Indian population is up to 3.4%, while the prevalence of class III malocclusion in Caucasians varies from 0.8 to 4.0% and rises to 13% in Japanese and Chinese populaces.[7]

Skeletal malocclusion is found to show characteristic dermatoglyphic patterns as explained by embryological origin of oral and dermatoglyphic patterns.[8] Facial development begins as early as the 4th week of gestation.[1, 8] Palate begins to develop in the 6th week and is completed by the 12th week of gestation. The digital ridge patterns are indicators of growth-related developmental patterns, which start to appear during the 12th week of gestation, to be completed by 24th week, after which they remain throughout life.[9]

A relationship has also been found to exist between the ABO blood group system and some diseases and maxillofacial deformities.[10-12] The ABO blood group is genetically determined as they are inherited co-dominantly through genes on chromosome 9 from both parents.[4] A person's ABO type is determined by the inheritance of 1 of 3 alleles (A, B, or O).[10] The presence or absence of these antigens results in the four blood groups: A, B, AB, and O.[9]

Malocclusion leads to long-term complications such as temporomandibular joint (TMJ) dysfunctions, periodontal disease, obstructive sleep apnea, psychological disorders, and articulation errors.[13-15] Late diagnosis of skeletal malocclusions leads patients to orthognathic surgery,[16] therefore, the orthodontist must have sound knowledge of dental occlusion and the underlying skeletal relationship of the patient to arrive at the correct diagnosis and treatment plan for the malocclusion.[5]

Dermatoglyphic investigation is a method of exploring the genetic associations of malocclusion [17] due to the fact that there is a strong association between dermatoglyphic patterns and sagittal skeletal discrepancies.[18] A study by Reddy et al.[19] found a significant association between different malocclusions and specific types of ridge pattern.

The relationship between the ABO blood group system and some oral diseases has been one of the most important human genetic traits.[20] A relationship exists between malocclusion and ABO blood group system, and given that both are related to genetic components, it may be stated that blood groups have an association with malocclusions.[4, 10] The strongest association between ABO blood group system and malocclusion was reported to be highest in blood group B, and least in blood group AB.[4] Dermatoglyphic and ABO blood group studies done in association with malocclusion yielded diverse results, which could be due to the fact that numerous other factors such as ethnic and racial variations, congenital, environmental, and other local factors can also influence the development of malocclusions.[19,21-23] More research is essential to ascertain the relationship between malocclusion with fingerprints and the blood groups in the Nigerian population.

This study is relevant to the field of orthodontics, particularly in preventive and interceptive orthodontics, for early diagnosis and correction of deviated growth patterns of the jaws. The objective of this study is to assess the relationship between fingerprint pattern and blood group with skeletal malocclusion in Nigerians.

Materials and Methods

Study design: This was a prospective cross-sectional study.

Study population and location: Patients seeking orthodontic treatment between the ages of 13 to 40 years old who met the selection criteria. The study was carried out in the Orthodontic clinic of the Department of Orthodontics, University of Benin Teaching Hospital, Benin City.

Selection criteria:

Inclusion criteria:

1. Patients with no history of orthodontic treatment.
2. Patients aged 13 years to 40 years old.
3. All patients who attended the orthodontic clinic, and gave written informed consent to participate in the study.
4. Patients without periodontal disease that may affect the positioning of the teeth.
5. Patients with full complement of teeth, excluding third molars.
6. All subjects were of Nigerian descent.

Exclusion criteria:

1. Patients with malformation syndromes or other craniofacial abnormalities associated with maxilla and mandible, and those with facial asymmetry and acquired skeletal defects.
2. Patients with congenital or acquired deformities of the fingers and amputated fingers.
3. Patients with skin diseases, with wounds or scars on the fingers.
4. Patients with periodontal conditions that may affect the positioning of the teeth.
5. Patients with previous extraction of the teeth, particularly the first molar.

Sample size determination and selection

The sample size was calculated using quantitative data formula:

$$n = \left[z \frac{\frac{\alpha}{2}}{E} \sigma \right]^2$$

= [13.62]2 =185.55=186

Where n is the sample size, a 95% degree confidence interval corresponds to α=0.05, z the standard normal deviation, E the margin of error E=1 and standard deviation=6.95.

Materials and methods

The sagittal jaw relation was determined from the patient's lateral cephalogram with assessment of the following parameters: SNA, SNB, ANB and FMA.[18] Cephalometric norms of the Nigerian population were used to group the patients' skeletal patterns (appendix I).[24] The type of malocclusion was classified using Steiner's analysis for skeletal maloccl;usion (ANB angle) into three groups: Skeletal Class 1, Skeletal Class 2 and Skeletal Class 3.[16,25] The FMA was used to determine the vertical jaw relationship.[26]

The fingerprints recording was done by the researcher, the hands of the subjects were cleaned by the researcher with soap and water and dried with sterile gauze. The impression of individual digits was made by placing the bulb of the digits onto the surface of the bioscanner (see appendix IIa). The fingerprints were recorded with IBS software and analysed using the classification by Galton in 1892[1,23] as shown in Appendix IIIb.

The blood test of the individual was done to determine their blood group by the researcher, in conjunction with a medical laboratory scientist.[27] Antisera A, B, and D were used, with blood samples from the participants (appendix IV). The presence of agglutination with antiserum A confirmed blood group A. The presence of agglutination with antiserum B confirmed blood group B. The absence of agglutination on both antisera A and B confirmed blood group O, and the presence of agglutination on both antisera A and B confirmed blood group AB. The presence of agglutination with antiserum D confirmed Rhesus positive blood group. The absence of agglutination with antiserum D confirmed Rhesus negative blood group. The patient's blood group was determined and recorded on a data collection form (see appendix V).

Ethical considerations

Ethical approval for this study was obtained from the Ethics and Research Committee, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria (protocol number: ADM/E22/A/VOL. VII/14682). Informed consent was obtained from study participants or their parents/ caregiver for minors. Each participant filled the informed consent form and the minor gave assent before they were recruited into the study.

Results

Sociodemographic characteristics

A total of 205 participants were examined, among them, 121 (59.0%) were females and 84 (41.0%) were males. The mean age was 24.86 ± 7.02 and the age ranged from 13 – 40 years, and the most common age group was 21 – 25 years (28.8%). A majority of the patients had blood group O, 143 (69.8%), the ulnar loop was the most common dermatoglyphic pattern at 1266 (61.8%), while skeletal class 1 at 114 (55.6%) was the most common skeletal malocclusion.

Table 1a: Distribution of patients' characteristics

Characteristic	Frequency N = 205	(%)
Age group (in years)		
13 – 15	16	7.8
16 – 20	46	22.4
21 – 25	59	28.8
26 – 30	41	20.0
31 – 35	19	9.3
36 – 40	24	11.7
Gender		
Male	84	41.0
Female	121	59.0
Blood group		14.1
A	29	
B	24	11.7
AB	9	4.4
O	143	69.8
Rhesus 'D' factor		
Positive	187	91.2
Negative	18	8.8
Dermatoglyphic pattern ([¶]***N=2,050*****)**		
Arch	210	10.2
Radial loop	71	3.5
Ulnar loop	1266	61.8
Whorl	503	24.5
Skeletal malocclusion pattern		
1	114	55.6
2	34	16.6
3	57	27.8

Table 1b: Vertical and sagittal skeletal measurement in degrees

ANB (Median (IQR)	3.0 (1.0 – 4.0)
FMA (Median (IQR)	22.0 (20.5 – 24.0)

Table 2: Association of dermatoglyphic patterns with skeletal malocclusion.

	Fingerprint pattern	Skeletal pattern 1 (%)	Skeletal pattern 2 (%)	Skeletal pattern 3 (%)	p-value
Left fifth finger	Arch	6 (5.3)	0 (0)	0 (0)	**<0.001**
	radial loop	2 (1.8)	0 (0)	0 (0)	
	ulnar loop	92 (80.7)	26 (76.5)	57 (100)	
	Whorl	14 (12.3)	8 (23.5)	0 (0)	
Left fourth finger	Arch	6 (5.3)	2 (5.9)	6 (10.5)	0.781
	radial loop	6 (5.3)	0 (0)	2 (3.5)	
	ulnar loop	73 (64.0)	24 (70.6)	36 (63.2)	
	Whorl	29 (25.4)	8 (23.5)	13 (22.8)	
Left index finger	Arch	20 (17.5)	1 (2.9)	11 (19.3)	**0.0345**
	radial loop	8 (7.0)	8 (23.5)	3 (5.3)	
	ulnar loop	45 (39.5)	16 (47.1)	25 (43.9)	
	Whorl	41 (36.0)	9 (26.5)	18 (31.6)	
Left middle finger	Arch	19 (16.7)	9 (26.5)	8 (14.0)	0.603
	radial loop	4 (3.5)	0 (0)	0 (0)	
	ulnar loop	68 (59.6)	19 (55.9)	38 (66.7)	
	Whorl	23 (20.2)	6 (17.6)	11 (19.3)	
Left thumb	Arch	20 (17.5)	5 (14.7)	8 (14.0)	**0.006**
	radial loop	3 (2.6)	5 (14.7)	0 (0)	
	ulnar loop	55 (48.2)	10 (29.4)	19 (33.3)	
	Whorl	36 (31.6)	14 (41.2)	30 (52.6)	
Right fifth finger	Arch	5 (4.4)	0 (0)	2 (3.5)	0.534
	radial loop	2 (1.8)	0 (0)	0 (0)	
	ulnar loop	95 (83.3)	32 (94.1)	53 (93.0)	
	Whorl	12 (10.5)	2 (5.9)	2 (3.5)	
Right fourth finger	Arch	3 (2.6)	3 (8.8)	2 (3.5)	0.207
	radial loop	0 (0)	0 (0)	2 (3.5)	
	ulnar loop	75 (65.8)	23 (67.6)	40 (70.2)	
	Whorl	36 (31.6)	8 (23.5)	13 (22.8)	
Right index finger	Arch	15 (13.2)	5 (14.7)	8 (14.0)	0.683
	radial loop	9 (7.9)	4 (11.8)	5 (8.8)	
	ulnar loop	61 (53.5)	15 (44.1)	23 (40.4)	
	Whorl	29 (25.4)	10 (29.4)	21 (36.8)	
Right middle finger	Arch	11 (9.6)	7 (20.6)	5 (8.8)	0.302
	radial loop	0 (0)	0 (0)	1 (1.8)	
	ulnar loop	87 (76.3)	25 (73.5)	43 (75.4)	
	Whorl	16 (14.0)	2 (5.9)	8 (14.0)	
Right thumb	Arch	14 (12.3)	6 (17.6)	3 (5.3)	**0.048**
	radial loop	7 (6.2)	0 (0)	0 (0)	
	ulnar loop	51 (44.7)	10 (29.4)	30 (52.6)	
	Whorl	42 (36.8)	18 (52.9)	24 (42.1)	

Fisher's exact test

The association between dermatoglyphic patterns and skeletal malocclusion is shown in Table 2. Arch was the most seen in the left thumb, index, and middle fingers of individuals with skeletal pattern I malocclusion. It was absent in the left fifth fingers of participants with skeletal patterns II and III malocclusion. Radial loop was most seen in the left index finger and right index finger of individuals with skeletal pattern II malocclusion. However, it was absent in the left fifth finger, left fourth finger, left middle finger and right fifth finger of participants with skeletal pattern II malocclusion. Ulnar loop pattern was most seen in the right and left fifth fingers of participants with skeletal pattern I malocclusion. Whorl pattern was seen more in the right thumb of individuals with skeletal pattern III and left index finger of individuals with skeletal pattern I malocclusion. But the whorl pattern was absent in the left fifth finger and right middle finger of participants with skeletal pattern III malocclusion. A significant association exists between dermatoglyphic patterns and skeletal malocclusion, with the ulnar loop patterns of left fifth finger (p = <0.001), in association with skeletal pattern III and left index finger (p = 0.035) in associated with skeletal pattern II malocclusion. The whorl pattern of the left thumb (p = 0.006) is associated with skeletal pattern III and the whorl pattern of the right thumb (p = 0.048) was found to be associated with skeletal pattern II malocclusion

Table 3: Correlation of dermatoglyphic patterns of study participants with categories of Skeletal malocclusion

Digit	Dermatoglyphic pattern	Skeletal pattern 1 *N=114* No(%)	Skeletal pattern 2 *N=34* No(%)	Skeletal pattern 3 *N=57* No(%)	Kendall's tau ($_b$)	p-value
Left Thumb	Arch	20 (17.5)	5 (14.7)	8 (14.0)		
	radial loop	3 (2.6)	5 (14.7)	0 (0)	0.136	**0.029**
	ulnar loop	55 (48.2)	10 (29.4)	19 (33.3)		
	Whorl	36 (31.6)	14 (41.2)	30 (52.6)		
Left Index finger	Arch	20 (17.5)	1 (2.9)	11 (19.3)		
	radial loop	8 (7.0)	8 (23.5)	3 (5.3)	-0.030	0.636
	ulnar loop	45 (39.5)	16 (47.1)	25 (43.9)		
	Whorl	41 (36.0)	9 (26.5)	18 (31.6)		
Left Middle finger	Arch	19 (16.7)	9 (26.5)	8 (14.0)		
	radial loop	4 (3.5)	0 (0)	0 (0)	0.013	0.835
	ulnar loop	68 (59.6)	19 (55.9)	38 (66.7)		
	Whorl	23 (20.2)	6 (17.6)	11 (19.3)		
Left Ring finger	Arch	6 (5.3)	2 (5.9)	6 (10.5)		
	radial loop	6 (5.3)	0 (0)	2 (3.5)	-0.037	0.578
	ulnar loop	73 (64.0)	24 (70.6)	36 (63.2)		
	Whorl	29 (25.4)	8 (23.5)	13 (22.8)		
Left Fifth finger	Arch	6 (5.3)	0 (0)	0 (0)		
	radial loop	2 (1.8)	0 (0)	0 (0)	-0.019	0.727
	ulnar loop	92 (80.7)	26 (76.5)	57 (100)		
	Whorl	14 (12.3)	8 (23.5)	0 (0)		
Right Thumb	Arch	14 (12.3)	6 (17.6)	3 (5.3)		
	radial loop	7 (100.0)	0 (0)	0 (0)	0.097	0.104
	ulnar loop	51 (44.7)	10 (29.4)	30 (52.6)		
	Whorl	42 (36.8)	18 (52.9)	24 (42.1)		
Right Index finger	Arch	15 (13.2)	5 (14.7)	8 (14.0)		
	radial loop	9 (7.9)	4 (11.8)	5 (8.8)	0.049	0.447
	ulnar loop	61 (53.5)	15 (44.1)	23 (40.4)		
	Whorl	29 (25.4)	10 (29.4)	21 (36.8)		

Right Middle finger	Arch	11 (9.6)	7 (20.6)	5 (8.8)		
	radial loop	0 (0)	0 (0)	1 (1.8)	-0.037	0.569
	ulnar loop	87 (76.3)	25 (73.5)	43 (75.4)		
	Whorl	16 (14.0)	2 (5.9)	8 (14.0)		
Right Ring finger	Arch	3 (2.6)	3 (8.8)	2 (3.5)		
	radial loop	0 (0)	0 (0)	2 (3.5)	-0.108	0.090
	ulnar loop	75 (65.8)	23 (67.6)	40 (70.2)		
	Whorl	36 (31.6)	8 (23.5)	13 (22.8)		
Right Fifth finger	Arch	5 (4.4)	0 (0)	2 (3.5)		
	radial loop	2 (1.8)	0 (0)	0 (0)	-0.046	0.470
	ulnar loop	95 (83.3)	32 (94.1)	53 (93.0)		
	Whorl	12 (10.5)	2 (5.9)	2 (3.5)		

Table 3 shows the distribution and relationships of the categories of skeletal malocclusion to the participants' fingerprint patterns. When considered in categories, the proportion of participants with the whorl fingerprint pattern on the left thumb appeared to increase as the class of skeletal malocclusion increased. This monotonic relationship was confirmed on Kendall's tau-b test, which demonstrated a weak positive correlation of fingerprint patterns of the left thumb with increasing classes of skeletal malocclusion, which was statistically significant ($_b$ = 0.136, p = 0.029). The ulnar loop pattern was the dominant fingerprint pattern in the left index and fifth finger, even though it did not appear to demonstrate a clear monotonic relationship with the classes of skeletal malocclusion as in the thumb. The fingerprint patterns on the other digits of the left hand were not related to the classes of skeletal malocclusion in the study participants.

On the right hand, all participants with a radial loop on their thumbs had the least class of skeletal malocclusion (100% vs 0%, p = 0.043). No clear monotonic relationship was found between participants' fingerprint patterns on any other digit and the class of skeletal malocclusion (p>0.05).

Table 4a: Relationship between participants' dermatoglyphic patterns and quantitative measures of skeletal malocclusion

Hand	Digit	Dermatoglyphic pattern	No(%)	ANB (°) Median (IQR)	p-value	FMA (°) Median (IQR)[¶]	p-value
Left	Thumb	Arch	33 (16.1)	3.0 (2.0 – 4.0)	0.127	22.0 (21.1 – 24.8)	0.141
		Radial loop	8 (3.9)	6.0 (2.0 – 9.0)		24.0 (21.3 – 28.3)	
		Ulnar loop	84 (41.0)	2.8 (2.0 – 4.0)		22.0 (20.6 – 23.0)	
		Whorl	80 (39.0)	3.0 (1.0 – 4.0)		21.8 (20.0 – 24.0)	
	Index finger	Arch	32 (15.6)	2.0 (-0.5 – 3.0)	**0.037**[a]	22.0 (20.0 – 23.9)	**0.029**[b]
		Radial loop	19 (9.3)	3.5 (2.0 – 5.0)		23.0 (22.0 – 25.0)	
		Ulnar loop	86 (42.0)	2.5 (1.3 – 4.0)		21.5 (20.0 – 23.0)	
		Whorl	65 (31.7)	3.0 (1.0 – 4.0)		22.0 (20.5 – 24.0)	

	Arch	36 (17.5)	3.0 (2.0 – 5.0)		22.5 (22.0 – 25.0)	
	Radial loop	4 (2.0)	2.5 (2.0 – 3.0)		21.0 (20.1 – 21.9)	
Middle finger	Ulnar loop	125 (61.0)	3.0 (1.0 – 4.0)	0.723	22.0 (20.0 – 23.0)	**0.026**[c]
	Whorl	40 (19.5)	3.0 (1.0 – 4.0)		22.8 (20.6 – 24.0)	
	Arch	14 (6.8)	2.0 (1.0 – 4.0)		22.0 (21.4 – 23.3)	
	Radial loop	8 (3.9)	2.0 (-0.3 – 2.4)		22.5 (20.1 – 23.9)	
Ring finger	Ulnar loop	133 (64.4)	3.0 (1.6 – 4.0)	0.416	22.0 (20.0 – 24.0)	0.845
	Whorl	50 (24.4)	3.0 (1.0 – 4.0)		22.0 (21.0 – 23.3)	
	Arch	6 (2.9)	2.0 (2.0 – 3.5)		26.0 (22.0 – 27.0)	
	Radial loop	2 (1.0)	NA		22.5 (22.0 – 23.0)	
Fifth finger	Ulnar loop	175 (85.4)	2.5 (1.0 – 4.0)	**0.019**[d]	22.0 (20.0 – 23.0)	**0.005**[e]
	Whorl	22 (10.7)	4.0 (2.8 – 5.0)		23.0 (21.5 – 25.0)	

Kruskal-Wallis test; NA – not applicable (both values were 3.0°)

Table 4b: Post-Hoc pairwise comparison of median values of ANB and FMA between dermatoglyphic patterns of the left hand

Hand	Digit	Paired Dermatoglyphic pattern	Test statistic (ANB)	p-value	Test statistic (FMA)	p-value
		Arch vs Radial loop	172.0	0.009	181.0	0.016
		Arch vs Whorl	795.0	0.028	934.0	0.252
	Index finger	Arch vs Ulnar loop	1113.0	0.107	1352.5	0.886
		Radial loop vs Whorl	501.5	0.133	471.5	0.071
		Ulnar loop vs Whorl	2752.0	0.527	2561.0	0.183
		Ulnar loop vs Radial loop	600.5	0.069	476.5	0.004
		Arch vs Radial loop	NA	NA	29.5	0.053
		Arch vs Whorl	NA	NA	611.5	0.257
Left	**Middle finger**	Arch vs Ulnar loop	NA	NA	1576.5	0.006
		Radial loop vs Whorl	NA	NA	49.5	0.210
		Ulnar loop vs Whorl	NA	NA	2169.5	0.206
		Ulnar loop vs Radial loop	NA	NA	188.5	0.399
		Arch vs Radial loop	4.0	0.465	3.0	0.429
		Arch vs Whorl	34.5	0.071	45.5	0.247
	Fifth finger	Arch vs Ulnar loop	499.0	0.835	199.5	0.009
		Radial loop vs Whorl	15.0	0.455	19.0	0.752
		Ulnar loop vs Whorl	1148.5	0.002	1284.0	0.010
		Ulnar loop vs Radial loop	144.0	0.664	133.0	0.557

Mann-Whitney U test; NA – Not applicable.

Table 4a: Relationship between participants' dermatoglyphic patterns and quantitative measures of skeletal malocclusion (Contd)

Hand	Digit	Dermatoglyphic pattern	No(%)	ANB (°) Median (IQR)	p-value	FMA (°) Median (IQR)¶	p-value
		Arch	23 (11.2)	3.0 (2.0 – 4.0)		22.0 (21.1 – 24.8)	
		Radial Loop	7 (3.4)	6.0 (2.0 – 9.0)		24.0 (21.3 – 28.3)	
	Thumb	Ulnar Loop	91 (44.4)	2.8 (2.0 – 4.0)	0.127	22.0 (20.6 – 23.0)	0.141
		Whorl	84 (41.0)	3.0 (1.0 – 4.0)		21.8 (20.0 – 24.0)	
		Arch	28 (13.6)	2.0 (-0.5 – 3.0)		22.0 (20.0 – 23.9)	
		Radial Loop	18 (8.8)	3.5 (2.0 – 5.0)		23.0 (22.0 – 25.0)	
Right	**Index finger**	Ulnar Loop	99 (48.3)	2.5 (1.3 – 4.0)	**0.037**[a]	21.5 (20.0 – 23.0)	**0.029**[b]
		Whorl	60 (29.3)	3.0 (1.0 – 4.0)		22.0 (20.5 – 24.0)	
		Arch	23 (11.2)	3.0 (2.0 – 5.0)		22.5 (22.0 – 25.0)	
		Radial Loop	1 (0.5)	2.5 (2.0 – 3.0)		21.0 (20.1 – 21.9)	
	Middle finger	Ulnar Loop	155 (75.6)	3.0 (1.0 – 4.0)	0.723	22.0 (20.0 – 23.0)	**0.026**[c]
		Whorl	26 (12.7)	3.0 (1.0 – 4.0)		22.8 (20.6 – 24.0)	
		Arch	8 (3.9)	2.0 (1.0 – 4.0)		22.0 (21.4 – 23.3)	
		Radial Loop	2 (1.0)	2.0 (-0.3 – 2.4)		22.5 (20.1 – 23.9)	
	Ring finger	Ulnar Loop	138 (67.3)	3.0 (1.6 – 4.0)	0.416	22.0 (20.0 – 24.0)	0.845
		Whorl	57 (27.8)	3.0 (1.0 – 4.0)		22.0 (21.0 – 23.3)	
		Arch	7 (3.4)	2.0 (2.0 – 3.5)		26.0 (22.0 – 27.0)	
		Radial Loop	2 (1.0)	NA		22.5 (22.0 – 23.0)	
	Fifth finger	Ulnar Loop	180 (87.8)	2.5 (1.0 – 4.0)	**0.019**[d]	22.0 (20.0 – 23.0)	**0.005**[e]
		Whorl	16 (7.8)	4.0 (2.8 – 5.0)		23.0 (21.5 – 25.0)	

Kruskal-Wallis test; NA[1] – Not applicable (value was -2.0); NA[2] – Not applicable (FMA value was 20.0); NA[3] – Not applicable (ANB value was 2.0).

Table 4b: Post-Hoc pairwise comparison of median values of ANB and FMA between dermatoglyphic patterns of the right hand (Contd)

Hand	Digit	Paired Dermatoglyphic pattern	Test statistic	p-value
		Arch vs Radial loop	41.5	0.053
		Arch vs Whorl	683.5	0.031
		Arch vs Ulnar loop	579.0	0.001
Right	**Thumb**	Radial loop vs Whorl	261.0	0.621
		Ulnar loop vs Whorl	3518	0.361
		Ulnar loop vs Radial loop	311.5	0.922

Mann-Whitney U test

There were statistically significant differences in the median ANB angle of the participants' fingerprint patterns within the left index and fifth fingers. These differences were noted to exist specifically between the arch and radial loop pattern (p=0.009) and the arch and whorl pattern (p=0.028) of the left index finger; and the whorl and ulnar loop of the left fifth finger (p=0.009). Using the FMA as a measure of skeletal malocclusion, there were also significant differences in the median values of the left index, middle, and fifth fingers. The radial and ulnar loops (p=0.004) and arch and radial loops of the left index finger; the arch and ulnar loop of the left middle finger (p=0.006); and the arch and ulnar loop (p=0.009) and ulnar loop and whorl of the left fifth finger (p=0.010) all demonstrated statistically significant differences.

The median FMA of the study participants demonstrated significant differences based on their right thumbs fingerprint patterns only. This difference was particularly common among those with the arch and ulnar loop (p=0.001) and the arch and whorl (p=0.031) fingerprint patterns. The median ANB values were similar in all the study participants, irrespective of the type of fingerprint pattern they had (see Table 4 above).

Table 5: Association between ABO blood group and skeletal malocclusion

	Skeletal Pattern				
Characteristic	**Pattern 1**	**Pattern 2**	**Pattern 3**	**Total**	**p-value[1]**
Blood group A	13 (45.0%)	4 (14.0%)	12(41.0%)	29(100.0%)	
Blood group B	11 (45.8%)	2 (8.3%)	11 (45.8%)	24 (100.0%)	
Blood group AB	5 (56.0%)	2 (22.0%)	2 (22.0%)	9 (100.0%)	0.200
Blood group O	85 (59.4%)	26 (18.2%)	32(22.4%)	143 (100.0%)	
Total	114 (55.6%)	34 (16.6%)	57 (27.8%)	205 (100.0%)	

[1]Fisher's exact test

As shown in Table 5 above, most of the individuals with blood group A (45%) had skeletal pattern I malocclusion; skeletal patterns 1 and 2 were equally dominant in individuals with blood group B (46%); Also, most of the individuals with blood group AB (56%) as well as blood group O (59%) had skeletal pattern 1 malocclusion. However, there was no statistically significant association between blood group and skeletal malocclusion (p = 0.200).

Concerning the Rhesus blood group, most of the individuals who were Rhesus positive (57.0%) had skeletal pattern 1 malocclusion; skeletal pattern 1 and 3 malocclusion were equally dominant in individuals with Rhesus negative (44.4%). There was no statistically significant association between rhesus and skeletal malocclusion (p = 0.300). Table 6

Table 6: Association between Rhesus blood group and skeletal malocclusion

	Skeletal Pattern				
Characteristic	**Pattern 1**	**Pattern 2**	**Pattern 3**	**Total**	**p-value[1]**
Rhesus Blood group					0.300
Positive	106 (57.0%)	32 (17.0%)	49 (26.0%)	187(100.0%)	
Negative	8 (44.4%)	2 (11.1%)	8 (44.4%)	18 (100.0%)	
Total	114 (55.6%)	34 (16.6%)	57 (27.8%)	205(100.0%)	

[1]Fisher's exact test

Table 7: Relationship between participants' blood groups and quantitative measures of skeletal malocclusion

Blood group	No(%)	ANB (°) Median (IQR)	p-value	FMA (°) Median (IQR)¶	p-value
A	29 (14.1)	2.0 (1.0 – 3.5)		22.0 (20.5 – 23.0)	
B	24 (11.7)	1.5 (-1.0 – 4.0)	0.053	21.3 (20.0 – 23.4)	0.794
AB	9 (4.4)	3.0 (1.5 – 5.0)		22.0 (20.5 – 24.0)	
O	143 (69.8)	3.0 (2.0 – 4.0)		22.0 (20.5 – 24.0)	
Rhesus D pos	187 (91.2)	3.0 (1.5 – 4.0)	0.719§	22.0 (20.5 – 24.0)	0.872§
Rhesus D neg	18 (8.8)	3.0 (1.0 – 4.0)		21.5 (20.4 – 23.3)	

¶Kruskal-Wallis test; §Mann-Whitney U test

Table 8: Correlation of participants' blood groups with categories of skeletal malocclusion

Blood Group	Skeletal pattern 1 *N=114* No (%)	Skeletal pattern 2 *N=34* No (%)	Skeletal pattern 3 *N=57* No (%)	Kendall's tau (τ_b)	p-value
A	13 (11.4)	4 (11.8)	12 (21.1)		
B	11 (9.6)	2 (5.9)	11 (19.3)	-0.143	**0.031**
AB	5 (4.4)	2 (5.9)	2 (3.5)		
O	85 (74.6)	26 (76.5)	32 (56.1)	0.089	0.225
Rhesus D pos	106 (93.0)	32 (94.1)	49 (86.0)		
Rhesus D neg	8 (7.0)	2 (5.9)	8 (14.0)		

The median (IQR) ANB value in participants with blood group O was 3.0 (2.0 – 4.0) degrees while that of those with blood group B was 1.5 (-1.0 – 4.0). There was, overall, no significant difference between the median values of ANB across the ABO blood groups (p = 0.053). The median (IQR) FMA value was similar in the various ABO blood group types as well (p = 0.794). The same was true for the ANB and FMA values of the participants across their Rhesus antigen type (Table 7).

When considered in categories, the ABO blood groups tended to occur mostly in the skeletal pattern 1 malocclusion compared to other skeletal malocclusion patterns. The median (IQR) ANB value in participants with blood group O was 3.0 (2.0 – 4.0) degrees while that of those with blood group B was 1.5 (-1.0 – 4.0). There was overall, no significant difference between the median values of ANB across the blood groups (p = 0.053). The median (IQR) FMA value was similar in the various blood group types as well (p = 0.794). The same was true for the ANB and FMA values of the participants across their Rhesus antigen type. Skeletal malocclusion related weakly and positively with rhesus antigen positivity, though this was not statistically significant (Table 8).

Table 9: Multivariate analysis of predictors of skeletal malocclusion in study participants

Variable	Adjusted Odds Ratio	95% Confidence Interval	p-value
ABO Blood Group			
A	3.32	0.90 – 12.22	0.071
B	**9.62**	**1.24 – 74 .46**	**0.030**
AB	1.13	0.20 – 6.34	0.887
O	1.000		
Left thumb			
Arch	0.44	0.09 – 2.22	0.316
Radial loop	1.57×10^9	0.00 – ∞	0.999
Ulnar loop	0.71	0.23 – 2.15	0.545
Whorl	1.000		
Left index finger			
Arch	0.90	0.26 – 3.10	0.861
Radial loop	1.34	0.24 – 7.51	0.738
Ulnar loop	0.82	0.32 – 2.11	0.685
Whorl	1.000		
Left fifth finger			
Arch	0.92	0.10 – 8.50	0.941
Radial loop	0.00	0.00 – ∞	0.999
Ulnar loop	**2.53**	**1.23 – 5.23**	**0.012**
Whorl	1.000		
Right thumb			
Arch	5.60	0.66 – 47.78	0.115
Radial loop	0.40	0.03 – 5.56	0.498
Ulnar loop	2.75	0.96 – 7.91	0.060
Whorl	1.000		

Further analyses were carried out to explore prediction of skeletal malocclusion in this cohort (Table 9).

Variables that demonstrated a p-value of <0.10 in bivariate analysis were selected and put in a model to predict higher classes of skeletal malocclusion. They included the ABO blood group, left thumb, index and fifth finger and right thumb. After adjusting for confounders, blood group B and an ulnar loop fingerprint pattern on the left fifth finger independently predicted higher classes of skeletal malocclusion. Participants with blood group B compared to those with group O had about 10 times greater odds of having higher classes of skeletal malocclusion (OR – 9.6 95%CI: 1.2 – 74.5) while possessing an ulnar loop on the left fifth finger compared to possessing a whorl pattern increased the odds of a higher class of malocclusion by 1.5 times (OR – 2.5, 95%CI: 1.2 – 5.2).

Discussion

Genetic and environmental factors play a role in the development of malocclusion that can affect the general health of patients depending on its degree of severity.[28] The orofacial structures and the epidermal ridges are derivatives of ectoderm of the embryonic tissue.[28]Understanding this biology may play a role in early diagnosis and treatment plan, thereby decreasing the burden of the condition in orofacial region.[28]

This study assessed the relationship between skeletal malocclusions with fingerprints and blood group as against the background of the role of genetic and environmental factors in the development of malocclusion.

In this study, the most common skeletal pattern was skeletal pattern 1 malocclusion, followed by skeletal pattern 3 and skeletal pattern 2 malocclusion. The most common dermatoglyphic pattern seen among study participants was ulnar loop, followed by whorl, arch and radial loop and is like previous findings in Nigeria by Mohammed et al.,[29]in the Kanuri ethnic group. Also, Ujaddughe et al.,[30] in their assessment of dermatoglyphic patterns and sex distribution in Esan ethnic group of Edo state, observed that the loop pattern had the highest frequency followed by whorl, arch and double whorl.[30] These findings suggest a variable prevalence of fingerprint patterns in Nigerians. Blood group O and Rhesus positive were most predominant among the participants with AB and Rhesus negative being the least prevalent. This was in concordance with other studies done in Nigeria[31-33], which found Blood group O to be most prevalent and AB to be the least prevalent in the ABO blood group and Rhesus positive to be most prevalent in the Rhesus blood group system.

The dermatoglyphic pattern seen in this study showed that the ulnar loop had the most dominant pattern across all types of skeletal malocclusion, with absence of arch and radial loop patterns on the left fifth fingers in skeletal class 2 and 3 malocclusions. While possessing an ulnar loop on the left fifth finger compared to having a whorl pattern increased the chances of a higher class of malocclusion by 1.5 times. The dermatoglyphic patterns of four fingers out of the ten fingers (left thumb, left index finger, left fifth finger and Right thumb) had a significant relationship with the different classes of skeletal malocclusion. The ulnar loop pattern of the left fifth finger is associated with skeletal pattern 3, and the left index finger is associated with skeletal pattern 2 malocclusion. The whorl pattern of the left thumb is associated with skeletal pattern 3 malocclusion and whorl pattern of the right thumb is found to be associated with skeletal pattern 2 malocclusion. The left hand had more digits with a significant relationship with skeletal malocclusion. This finding is comparable to that of George et al.[18] and in contrast with the findings of Kaur et al.,[34]who found no significant correlation between dermatoglyphics and different skeletal patterns. The contrasting findings may be due to differences in sample size, which was smaller, and the fingerprint method used in the study.[34] Reddy et al.,[19]also reported significant association between skeletal malocclusion and specific types of ridge patterns as seen in this study. While different researchers have reported different frequencies of occurrence of specific dermatoglyphic patterns with different classes of skeletal malocclusion. It is understandable that their divergent findings may be due to differences in population studied among other factors because the cohort in this present study consisted of those with some degree of malocclusion and a relatively uniform population.

The bivariate analysis of blood groups with skeletal malocclusion did not establish any relationship in this study. However, the multivariate analysis shows that blood group B when compared with other blood groups was found to be directly related to higher classes of skeletal malocclusion. This aligns with the findings by Gheisari et al.[35] which revealed that blood groups B and AB have an increased incidence of association with maxillofacial deformities, whereas, blood groups O and A have a lower incidence of association in Iranian populations. A contrary opinion was, however, held by Shokor et al.,[36]who reported no genetic influence of ABO blood group in relation to variations in craniofacial morphology. The reason for this may be due to the difference in the study methodologies.

The dermatoglyphic patterns of individuals remain constant throughout life, from birth till death and have been found to have a relationship with malocclusion, although, it requires more research to be done. This easy, accessible, inexpensive, useful, reliable, and non-invasive method may be a useful tool if employed in clinical settings to aid early assessment of risk for malocclusion, along with diagnostic impression of sagittal skeletal relationships of maxilla and mandible in malocclusion. This might aid early preventive and interceptive orthodontic management of malocclusion if established, especially in developing countries with enormous populations and limited health budgets. In addition, the practice of routine recording of the fingerprints of patients in the orthodontic clinic along with other orthodontic records will go a long way in assisting forensic investigations and anthropology studies.

The sample size was a limitation, the participants were all hospital patients. No participants with normal occlusion were recruited in the study and this led to some assumptions in the regression model.

Conclusion

This study was able to show that there is a relationship between dermatoglyphic pattern with skeletal malocclusions. The possession of ulnar loop on the left fifth finger compared to the possession of whorl pattern increased the odds of a higher class of malocclusion by 1.5 times. There is a marked absence of the arch and radial loop patterns on the left fifth fingers in skeletal class 2 and 3 malocclusions. The ulnar loop patterns of left fifth finger and left index finger were associated with skeletal pattern 3 and skeletal pattern 2 malocclusion respectively. The whorl pattern of the left thumb was associated with skeletal pattern 3 malocclusion while the whorl pattern of the right thumb was found to be associated with skeletal pattern 2 malocclusion. There was no significant association between blood group and skeletal malocclusion. However, possession of blood group B, when compared with other blood groups, was found to be directly related to higher classes of skeletal malocclusion.

The dermatoglyphic patterns of some digits show predictive values, this relationship could be further studied in more races and in larger populations before being employed as a diagnostic aid for identifying malocclusion problems at an early age for timely orthodontic intervention.

Recommendation:

The dermatoglyphic patterns show the promise of being a predictive tool in skeletal malocclusion, thus, more research in different races and in larger sample populations is needed to further determine the extent of its use. The inclusion of participants with normal occlusion in future studies will aid comparison as well as test the specificity and sensitivity of dermatoglyphic patterns as a tool.

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Correlations between Cephalometric Measurements of Hard Tissues and Photogrammetric Features of Facial Soft Tissues.

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Abstract

Background: Facial soft tissues cover the teeth and the facial skeleton; maintain close anatomical relations with them and may nevertheless vary in their morphology and position. The objective of this study was to determine the correlations between soft facial tissue measurements and craniofacial hard tissue measurements..

Methods: A cross-sectional descriptive study was performed using standardised tele-radiographic and photographic images of young children who had come for orthodontic care. On each selected subject, cephalometric and photogrammetric measurements were made. The data collected was analysed using the IBM SPSS 20.0 statistical software. The correlation between hard tissue cephalometric measurements and photogrammetric soft tissue measurements was investigated by a Pearson correlation. The significance is fixed at $p = 0.05$.

Results: ANB was significantly and positively correlated to Sn-N'-Sm. I / A-Pog was significantly and positively correlated with Ls-E and Li-E. Significant and positive correlations were found between the position of the pogonion and Sn-H. It is the same between the position of point A and Trg-Sn distance; and between S-Ar and the variables N'-Sn and N'-Me '. Ar-Go was also significantly and positively correlated to Sn-Me ', Sn-Sts and N'-Me'.

Conclusion: The many significant and positive correlations found between cephalometric and photogrammetric variables show that these could advantageously be used to evaluate skeletal and dentoalveolar variables. This would limit the significant risks of ionizing radiation during orthodontic treatment.

Keywords: Photogrammetry, cephalometry, hard tissue, soft tissue

ORIGINAL ARTICLE

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Introduction

The photogrammetry of the soft tissues of the face is a measurement method that objectively quantifies the characteristics of the face through the photographic tool. Researchers have used it to evaluate the characteristics of the face [1,2] Unlike cephalometry, it is inexpensive and does not expose the patient to ionizing radiation. In addition, it is reliable and sufficiently reproducible because it is easy to achieve in a conventional context, without the need for special equipment.[1] Facial soft tissues cover the teeth and the facial skeleton, maintain close anatomical relationships with them and can vary considerably in their morphology and position. These variations may be related to the existence of inter-ethnic, racial and geographical variability in the facial skin tissues[2] but also to the existence of a positional and morphological variability of the underlying skeletal and dentoalveolar structures.[3] The formulation of a treatment plan based solely on cephalometric measurements of skeletal and dentoalveolar structures is therefore insufficient and often leads to aesthetic problems.[4-7] Therefore, it is necessary to have these cephalometric measurements coupled with photogrammetric measurements in order to better identify the skeletal and dentoalveolar abnormalities on the one hand and the cutaneous ones on the other, and their possible associations. However, little importance has been devoted to quantifying the relationships between the position or dimensions of the components of soft facial tissues and different skeletal and dentoalveolar parameters.

Most research in this area focuses on the study of cephalometric and photogrammetric projection and identification errors [8] and the response of soft tissues to the movements of orthopedic, orthodontic or orthognathic therapy.[9-12]
Separate cephalometric and photogrammetric measurements have been performed in a Senegalese population,[13,14] but no study of associations between these two parameters has been performed in this population. The objective of this study was to determine the correlations between the photogrammetric measurements of the face and different profile teleradiographic measurements in Senegalese subjects.

Materials and methods

It is a transversal analytical study carried out at the orthodontic clinic of the Department of Odontology of Cheikh Anta Diop University in Dakar. The study is based on a sample of a group of Senegalese children aged between 6 and 12 who came for consultation to the Dentofacial Orthopedics Clinic of the Department of Odontology of the Faculty of Medicine, Pharmacy and Dentistry of the Faculty of Medicine, Pharmacy and Dentistry of Cheikh Anta Diop University in Dakar. Subjects who received orthodontic or prosthetic treatment, plastic or orthognathic surgery were not included in the study. It is the same for those who had orofacial soft tissue pathologies (swelling, ulcerations ...) or severe craniofacial abnormalities. The pictures on which one could see a contracture of the muscles of the chin tassel (pleated or flattened chin) were also excluded from the study.

Photogrammetric recordings and measurements: On each subject selected according to the above criteria, a standardised profile photographic snapshot is made according to the method described by Ferrario et al.[15] All photos were taken with the same digital camera (Samsung type, with a resolution of 14.2 megapixels, optical zoom × 3). The images obtained were digitised on a computer using a photo software (photoshop type elements 7.0) with a resolution of 300 DPI (dot per inch or PPP point par pouce). These scanned images were printed on a white sheet from a single printer (HP Deskjet 3050). The magnification of the images obtained was calculated from that of the image of a metric scale taken as a reference. From that moment, the actual linear measurements could be obtained. The points and lines used for this approach are defined in Table I. The photogrammetric variables are defined in Table II and illustrated in Figures 1 and 2.

Cephalometric recording: Cephalometric measurements were then made from a tele-radiographic profile of each selected subject. Informed consent was obtained from the parents before the snapshot was taken. Plotting all the tele-radiographies was done manually by a single examiner (JD) on an acetate paper sheet. The points and lines chosen are defined in Table 1. The measured cephalometric variables are defined in Table II and anatomically illustrated in Figures 3 and 4.

Statistical analyses: The data collected was analysed using the IBM SPSS 20.0 statistics software for windows. The power of the association between photogrammetric measurements and cephalometric variables was sought by the Pearson correlation coefficient. The materiality threshold is set at $p = 0.05$.

Method error: The reliability of photogrammetric and cephalometric measurements was assessed by measuring again, at random, the variables in a group of 30 children (representing 30% of study subjects), one month after the first assessment. The Cronbach test was performed to determine the error of the method. An intra-class coefficient between 0.789 and 0.971 was found. This result shows that there is no significant difference between the first and second measurements.

Results:

One hundred subjects comprising 49 boys and 51 girls aged between 6 and 12 years with an average age of 9.5 ± 1.08 years were included in this study.

Correlations between Sagittal Photogrammetric Variables and Sagittal Teleradiographic Parameters

The position of point A was significantly and positively correlated with Trg-Sn ($r = 0.40$ and $p =$

0.04) and Sn-N'-Sm (r = 0.52 and p = 0.008). I / A-Pog was also significantly and positively correlated with Ls-E (r = 0.51 and p = 0.01), Li-E (r = 0.48 and p = 0.01), Ls-S (r = 0.47, p = 0.01) and Li / Sn-Sm (r = 0.46, p = 0.02). The convexity was significantly and positively correlated with Sn-N'-Sm (r = 0.41 and p = 0.04). It is the same between the position of the pogonion and the Sn-H photogrammetric variable (r = 0.42, p = 0.03). The ANB angle was also significantly and positively correlated with the Sn-N'-Sm angle (r = 0.52 and p = 0.009) (Table 3).

Correlations between vertical photogrammetric variables and vertical teleradiographic parameters

The N-Me height was significantly and positively correlated with Sn-Me 'and N'-Sn distances with r equal to 0.46 and 0.56 respectively; and p respectively equal to 0.02 and 0.004. This N-Me height was also significantly and positively correlated with Sti-Sm and N'-Me 'with r respectively equal to 0.66 and 0.67 and p values < 0.001. N-ENA was significantly and positively correlated to N'-Sn, Sti-Sm and N'-Me' with r respectively equal to 0.51; 0.55 and 0.56; and p respectively equal to 0.01; 0.001 and 0.004. ENA-Me was significantly and positively correlated with Sn-Me' (r = 0.48 and p = 0.01), N'-Sn (r = 0.51 and p = 0.01), Sn-Sts (r = 0.45 and p = 0.02), Sti-Sm (r = 0.55 and p = 0.005) and N'-Me '(r = 0.66 and p < 0.001). S-Go was significantly and positively correlated to the distances N'-Sn, Sn-Sts, Sti-Sm and N'-Me' with r respectively equal to 0.59; 0.41; 0.65 and 0.61 and p respectively equal to 0.002; 0.04; 0.001 and 0.001. The S-Ar height was significantly and positively correlated with N'-Sn distances (r = 0.63 and p = 0.001), Sti-Sm (r = 0.51 and p = 0.009) and N'-Me' (r = 0.55 and p = 0.005). The Ar-Go distance was significantly and positively correlated with Sn-Me ', N'-Sn, Sn-Sts, Sti-Sm, Sm-Me' and N'-Me' with r respectively equal to 0.41; 0.41; 0.48; 0.65; 0.42 and 0.55 and p respectively equal to 0.04; 0.04; 0.01; 0.001; 0.03 and 0.005. The Y axis was significantly and positively correlated with the Sm-Me '/ Li-Sm angle (r = 0.40 and p = 0.04) and negatively correlated with angle Z (r = -0.54 and p = 0.006). The gonadal angle was significantly and positively correlated with Sm-Me '/ Li-Sm (r = 0.43 and p = 0.03) (Table 4).

Figure 1: Sagittal photogrammetric variables: 1 = Trg-Sn; 2 = Sn-H; 3 = Ls-E; 4 = Ls-S; 5 = Ls / Sn-Sm; 6 = Li-S; 7 = Li-E; 8 = Li / Sn-Sm; 9 = Pog '/ Sn-Sm; 10 = Sn-N'-Sm.

Figure 2: vertical photogrammetric variables: 1 = Sn-Me '; 2 = Sn-Sts; 3 = Sti-Sm; 4 = Sm-Me '; 5 = N'-Sn; 6 = N'-Me '; 7 = Z-angle; 8 = Prn-Sn-Ls; 9 = Sn-Ls / Li-Sm; 10 = Sm-Me '/ Li-Sm.

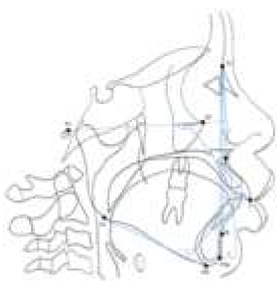

Figure 3: sagittal cephalometric variables: 1 = I / F; 2 = ANB; 3 = position of point A; 4 = convexity; 5 = I / A-Pog; 6 = sagittal position of the pogonion point; 7 = i / M.

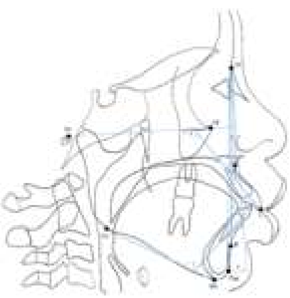

Figure 4: Vertical cephalometric variables: 1 = N-ENA; 2 = ENA-Me; 3 = N-Me; 4 = Y axis; 5 = S-Go; 6 = S-Ar; 7 = Ar-Go; 8 = angular / bony angle; 9 = FMA.

Table 1: Definition of points and lines used

Skin points and lines	Definitions
Nasion (N')	the point of the midline at the root of the nose
Pronasal (Prn)	the most salient point of the tip of the nose
Sub nasal (Sn)	the point where the upper lip joins the columella
Upper labial (Ls)	the point that indicates the mucocutaneous limit of the upper lip
Upper Stomion (Sts)	the lowest point of the upper lip
Lower stomion (Sti)	the highest point of the lower lip
Lower labial (Li)	the point that indicates the mucocutaneous border of the lower lip
Supramental (Sm)	the deepest point of the sub-labial lower concavity
Pogonion (Pog ')	the most anterior point of the chin
Chin (Me ')	the lowest point of the lower edge of the chin
Tragus (Trg)	the most posterior point of the atrial tragus
Suborbital (Or ')	perceptible point on the finger of the outer orbital rim
Line H	Line passing through the skin chin point and tangent to the upper lip
Line Sn-Sm	Aesthetic line of Canut, right joining Sn and Sm points
(Trg-Or ')	Frankfurt horizontal cutaneous plane, joining tragus and under orbital points
Line E	Ricketts E aesthetic line tangent to the tip of the nose and the tip of the chin
Line S	Line S is the line joining the point Pog and the middle between Prn and Sn
Line Z	line tangent to the chin and the most prominent lip
Skeletal and dentoalveolar points	
Nasion (N)	anteroposterior point of the image of the naso-frontal suture
Sella Turcica (S)	Sella Turcica (S)
Articulare (Ar)	point of the image of the posterior border of the ramus with the exocranial face of the occipital clivus
Porion (Po)	highest point of the external auditory canal located on the vertical passing through its middle
Anterior nasal spine (ANS)	tip of the anterior nasal spine
A	most sloping point of the concavity of the maxillary image
Orbital (Or)	lowest point of the orbit image
Upper Incisor (Ui)	free edge of the most anterior superior incisor
B	most sloping point of the concavity of the image of the symphysis
Chin (Ch)	lowest point of the image of the mandibular symphysis
Gonion (Go)	point equidistant from the most posterior point of the horizontal branch of the mandible, and from the lowest point of the rising branch
Pogonion (Pog)	most salient point of the image of the symphysis
Gnathion (Gn)	equidistant point between the point Pog and Me
Basion (Ba)	lowest point of the occipital basi

Table 2: Definition of chosen variables

Cephalometric variables	**Definitions**
I / A-Pog	distance from the incisal edge of the medial incisor superior to line A-Pog.
Sagittal position of the pogonion	distance between the point pogonion and the perpendicular to the Frankfurt plane passing through point Na.
Position of point A	distance between A and the perpendicular to PHF passing through point N
Convexity	distance from A to Na-Pog facial plane
I / F	angle that makes the axis of the upper incisor with the horizontal plane of Frankfurt
i / M	angle made by the axis of the lower incisor with the mandibular plane
ANB	maxillomandibular sagittal shift
N-Me	Total anterior facial height
N-ENA	upper anterior facial height
ENA-Me	lower anterior facial height
S-GB	total posterior head height
S-Ar	superior posterior head height
Ar-Go	lower posterior facial height
FMA	angle between the Frankfurt plane and the Downs mandibular plane
1- Y axis	angle formed by the line (SGn) and the Frankfurt plane
2- Gonic / Angular / Bony angle	angle formed by the mandibular plane (GoMe) and the tangent to the posterior edge of the mandible (ArGo).
1- Photogrammetric variables	
Trg- Sn	1- depth of the face
Ls-E	distance from the upper lip Ls to line E
Li-E	distance from lower lip Li to line E
Sn-H	distance from sub nasal point Sn to line H
Ls-S	distance from Ls to line S
Li-S	Li's distance to S line
Ls/ Sn- Sm	distance from Ls to Canut line (Sn-Sm)
Li/ Sn-Sm	distance from Li to Canut line (Sn-Sm)
Pog'/Sn- Sm	distance from Pog to Canut line (Sn-Sm)
Sn- N'- Sm	cutaneous ANB angle
Sn-Me’	lower third of the face
N'-Sn	nose length
Sn-Sts	length of the upper lip
Sti-Sm	length of the lower lip
Sm-Me’	chin height
N'-Me’	height of the lower floor
Prn-Sn-Ls	naso labial angle
Sn-Ls/Li-Sm	Inter labial angle
Sm-Me'/Li-Sm	Mento-labial angle
Z angle	formed by the intersection of the plane Frankfurt horizontal cutaneous (Trg-Or ') and line Z

Table 3: Correlations between sagittal photogrammetric variables and sagittal teleradiographic parameters

Settings / Parameters (mm,°)	I/A-Pog r (p)	Position Pog r (p)	Position A r (p)	Convexité r (p)	I/F r (p)	i/M r (p)	ANB r (p)
Trg-Sn	0.16 (0.43)	0.33 (0.11)	0.40* (0.04)	0.25 (0.22)	0.04 (0.83)	0.05 (0.81)	0.19 (0.35)
Ls-E	0.51* (0.01)	-0.22 (0.28)	0.09 (0.66)	0.36 (0.07)	-0.13 (0.52)	-0.02 (0.89)	0.25 (0.23)
Li-E	0.48* (0.01)	-0.36 (0.08)	-0.24 (0.25)	0.11 (0.60)	0.03 (0.88)	-0.26 (0.20)	-0.03 (0.86)
Sn-H	-0.28 (0.17)	0.42* (0.03)	0.24 (0.25)	-0.14 (0.50)	0.21 (0.32)	0.14 (0.51)	-0.03 (0.85)
Ls-S	0.47* (0.01)	-0.08 (0.68)	0.18 (0.39)	0.31 (0.13)	-0.07 (0.72)	0.01 (0.94)	0.26 (0.20)
Li-S	0.34 (0.10)	-0.39 (0.05)	-0.36 (0.08)	-0.02 (0.91)	-0.13 (0.53)	-0.16 (0.44)	-0,12 (0.55)
Ls/ Sn- Sm	0.14 (0.50)	0.19 (0.36)	0.39 (0.05)	0.25 (0.23)	-0.10 (0.61)	0.18 (0.38)	0.35 (0.09)
Li/ Sn-Sm	0.46* (0.02)	-0.1 (0.64)	-0.20 (0.33)	-0.04 (0.82)	0.11 (0.6)	-0.18 (0.39)	-0.10 (0.63)
Pog'/Sn- Sm	-0.01 (0.93)	0.30 (0.14)	0.09 (0.66)	0.11 (0.58)	0.19 (0.36)	0.08 (0.68)	0.01 (0.96)
Sn- N'- Sm	-0.08 (0.70)	0.28 (0.18)	0.52** (0.008)	0.41* (0.04)	-0.08 (0.70)	-0.03 (0.87)	0.52** (0.009)

***= The correlation is significant at the 0.05 level (bilateral). ** = The correlation is significant at the 0.01 level (bilateral).**

Table 4: Correlation between vertical photogrammetric variables and vertical teleradiographic Parameters

Parameters (mm,°)	N-Me r (p)	N-ENA r (p)	ENA-Me r (p)	S-Go r (p)	S-Ar r (p)	Ar-Go r (p)	FMA r (p)	Y Axis r (p)	Angular / Bony angle r (p)
Sn-Me'	0.46* (0.02)	0.39 (0.05)	0,48* (0.01)	0.38 (0.06)	0.25 (0.23)	0.41* (0.04)	-0.18 (0.4)	-0.11 (0.60)	0.17 (0.40)
N'-Sn	0.56** (0.004)	0.49* (0.01)	0.51* (0.01)	0.59** (0.002)	0.63** (0.001)	0.41* (0.04)	-0.19 (0.37)	0.02 (0.91)	-0.01 (0.92)
Sn-Sts	0.33 (0.11)	0.17 (0.41)	0.45* (0.02)	0.41* (0.04)	0.08 (0.69)	0.48* (0.01)	-0.10 (0.62)	0.07 (0.73)	-0.07 (0.74)
Sti-Sm	0.66** (<0.001)	0.62** (0.001)	0.55** (0.005)	0.65** (0.001)	0.51** (0.009)	0.65** (0.001)	-0.23 (0.26)	0.19 (0.35)	-0.20 (0.34)
Sm-Me'	0.38 (0.06)	0.30 (0.15)	0.40 (0.05)	0.33 (0.10)	0.25 (0.23)	0.42* (0.03)	0.01 (0.96)	0.18 (0.39)	0.27 (0.19)
N'-Me'	0.67** (<0.001)	0.56** (0.004)	0.66** (<0.001)	0.61** (0.001)	0.55** (0.005)	0.55** (0.005)	-0.18 (0.37)	0.02 (0.91)	0.08 (0.70)
Prn-Sn-Ls	0.08 (0.68)	-0.08 (0.68)	0.27 (0.19)	0.02 (0.89)	0.07 (0.74)	-0.03 (0.85)	0.39 (0.05)	0.29 (0.16)	-0.04 (0.83)
Sn-Ls/Li-Sm	-0.07 (0.74)	-0.12 (0.55)	0.01 (0.96)	-0.06 (0.75)	-0.09 (0.67)	-0.001 (0.99)	0.15 (0.46)	0.09 (0.67)	0.12 (0.55)
Sm-Me'/Li-Sm	-0.08 (0.71)	-0.11 (0.58)	-0.04 (0.85)	-0.07 (0.74)	-0.18 (0.37)	0.17 (0.42)	0.28 (0.17)	0.40* (0.04)	0.43* (0.03)
Z Angle	0.17 (0.42)	0.25 (0.23)	0.10 (0.63)	-0.04 (0.84)	-0.04 (0.83)	-0.09 (0.66)	-0.37 (0.07)	-0.54** (0.006)	-0.33 (0.11)

* = **The correlation is significant at the 0.05 level (bilateral). ** = The correlation is significant at the 0.01 level (bilateral).**

Discussion

The position of point A was significantly and positively correlated with Trg-Sn (r = 0.40 and p = 0.04). In other words, the deeper the face was, the closer point A was to the line perpendicular to the Frankfurt plane passing through the Nasion point. This correlation could be related to the fact that the advanced point A located on the maxillary alveolar rampart can cause that of the Sn point of the upper lip which rests on this alveolar rampart. When Sn moves forward, the Trg-Sn distance increases. Similarly, when A moves forward, its distance to the line perpendicular to the Frankfurt plane passing through the Nasion point decreases but the variable of the position of A increases since it is negatively noted.

The significant and positive correlations between the position of point A and Sn-N'-Sm on the one hand and between the convexity and Sn-N'-Sm on the other hand can be related to the simultaneous displacement of points A and Sn with the displacement of the maxillary alveolar rim and the upper lip which is overlying it. The further A point moves forward, the more its sagittal position increases as well as the convexity. Also, the more points Sn moves forward, the more the Sn-N'-Sm angle increases; hence the significant and positive correlations between these parameters. The value of the correlation coefficient between the position of point A and the Sn-N'-Sm angle of 0.52 shows a broad association between these two parameters; where the correlation coefficient between the convexity and Sn-N'-Sm of 0.41 (<0.5) shows a mean association according to Cohen [16].

Significant and positive correlations between I / A-Pog and Ls-E and Ls-S variables could also be explained by the relationship between the upper incisor and the upper lip. Several studies have shown that a retroversion of the upper incisor can lead to superior prostration [11,17]. Moreover, the orthodontic treatment of retraction of the upper incisors is often associated with a retraction of the upper lip which concomitantly corrects the prostration. The fact that the upper incisor also rests on the upper part of the lower lip and flush with its free edge explains the significant and positive correlation between the variable I / A-Pog which indicates the degree of superior incisal protrusion and the Li-E distances (r = 0.48 and p = 0.01) and Li / Sn-Sm (r = 0.46, p = 0.02).

The position of the pogonion was significantly and positively correlated with the Sn-H distance (r = 0.42, p = 0.03). In fact, the distal displacement of the pogonion leads to that of the cutaneous chin. This induces a rotation of the H line around the most prominent point of the upper lip, which means a recoil of the segment located under the center of rotation and an advance of the segment located above the center of rotation. An increase in the Sn-H distance will follow (which means a decrease of this negatively noted variable); hence the significant and positive correlation between the position of the pogonion and the Sn-H variable.

The significant and positive correlation between the ANB and Sn-N'-Sm angles show that variations in maxillomandibular skeletal shift follow that of the maxillomandibular cutoff. Indeed, the Sn-N'-Sm angular photogrammetric variable represents the cutaneous ANB angle. The value r > 0.5 shows a wide association between maxillomandibular skeletal shift and maxillomandibular cutoff [16]. This strong association is justified by the fact that the different points which constitute these two angles are situated opposite one another. In fact, cephalometric point A is located opposite cutaneous point Sn. The same is true of the Nasion point (located at the level of the naso-frontal suture) and the Nasion point of the skin at the level of the nasal trellis. Point B (the most sloping point of the mandibular alveolar rim) is also opposite point Sm situated at the bottom of the labial sulcus. Similar results have been reported by Gomes & al. in a study involving a sample of 123 subjects, including 65 girls and 58 boys aged 7 to 12, with whom teleradiographic images and photographic images in profile were taken. The results of this study showed a significant and positive correlation between skeletal ANB and cutaneous ANB (r = 0.82, p <0.001) [18]. Adwani & al. also found similar results for a sample of 150 subjects, including 64 boys, and 86 girls aged 13-28, where r and p were 0.689 and 0.001, respectively [19].

Correlation between vertical photogrammetric variables and vertical teleradiographic parameters

The cephalometric variables N-Me, N-ENA, ENA-Me, S-Go, S-Ar and Ar-Go were all significantly and positively correlated with photogrammetric variables

N'-Sn, Sti-Sm and N'-Me'. In addition, the three variables N-Me, ENA-Me and Ar-Go were significantly and positively correlated with Sn-Me '. It is the same between the ENA-Me, S-Go and Ar-Go variables and the Sn-Sts photogrammetric parameter. Specifically, the Ar-Go variable was significantly and positively correlated with the Sm-Me photogrammetric variable. These significant and positive correlations between vertical linear teleradiographic variables and vertical linear photogrammetric variables show the close relationships between skeletal structures and their vertical cutaneous structures. Thus, vertical linear photogrammetric variables could be used to evaluate the linear variables of the skeletal structures in the vertical direction. The use of correlation coefficients makes it possible to obtain the value of cephalometric measurements from photogrammetric measurements. This contributes to a considerable reduction of the risks of irradiation of the subjects when it comes to evaluating the skeletal structures in the vertical direction.

Axis Y was significantly and positively correlated with Sm-Me '/ Li-Sm ($r = 0.40$ and $p = 0.04$) and negatively correlated with angle Z ($r = -0.54$ and $p = 0.006$). The gonadal angle was significantly and positively correlated with Sm-Me '/ Li-Sm ($r = 0.43$ and $p = 0.03$).

The significant and positive correlations between the Y axis (Frankfurt / S-Gn plane) and Sm-Me '/ Li-Sm on the one hand and between the gonic angle and Sm-Me' / Li-Sm on the other hand could be related to the concomitant displacement of the Gnathion points, Skeletal Chin and Cutaneous Chin all located in the chin area. Indeed, a recoil of the chin leads to that of the Gnathion points, skeleton chin and cutaneous chin, those which cause an increase in the angle of the Y axis and the Sm-Me '/ Li-Sm angle as well as an increase in the angle of the glands; hence these significant and positive correlations. The significant and negative correlation between the angle of the Y axis and the Z angle (between the Frankfurt plane and the straight line connecting the Chin point to the most prominent lip) can also be related to the displacement in the same direction of Gnathion and Chin points. A shift of the skin point towards the back causes a reduction of angle Z. On the other hand, a shift of the gnathion point towards the back causes an increase in the angle Y axis, which justifies the significant and negative correlation between the angle of the Y axis and angle Z.

Conclusion

These numerous correlations prove the close relationship between hard facial tissues and their overlapping skin tissues mainly with respect to vertical linear variables. Vertical linear photogrammetric variables of the soft cutaneous tissues could thus be used to evaluate the cephalometric variables of the hard tissues in the vertical direction, when the X-ray is considered too invasive. This helps to significantly reduce the risk of irradiation of subjects when evaluating facial skeletal structures for epidemiological purposes in studies involving a larger number of subjects.

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Pattern of Malocclusion seen at Aminu Kano Teaching Hospital, Kano Nigeria: A 5 Year Review

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Abstract

Background: Malocclusion involves irregular tooth alignment or occlusion beyond normal limits, influenced by genetic, environmental, and ethnic factors. It is a multifactorial condition without a single cause. Understanding malocclusion patterns across populations is essential for orthodontic treatment planning, especially as demand for corrective care continues to rise globally.

Methods: This retrospective cross-sectional study analysed data from 106 orthodontic patients aged 8 to 40 years seen at Aminu Kano Teaching Hospital (AKTH) from 2019 to 2024. All patients who presented at the Orthodontic clinic of AKTH were included in the study sample. Angles malocclusion types, overjet, overbite, crowding, diastema, and oral habits were assessed. Data was cleaned and processed in MS Excel and all statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20, SPSS Inc., Chicago, IL, USA. (SPSS).

Results: The 5-year study at Aminu Kano Teaching Hospital included (106) patients, predominantly female (65.7%), with an average age of 14.5 years. Most patients (40%) were aged 11-15 years. A large proportion of the subjects (64.4%) had Class I malocclusion, with low diastema prevalence (89.5% at 0-1 mm). Increased overjet affected 51.4% and 50.5% were affected by increased overbite. This shows that a small majority had increased overjet (51.4%) and increased overbite (50.5%), a few 16.2% had crossbite, and 7.6% anterior open bite, while a majority of the subjects 69.2% had tooth rotations. Malocclusion distribution showed no gender differences but varied by age. Class I malocclusion was highest in age groups <10 and >25 years, while anterior open bite was more prevalent in older age groups. Significant associations were found with overbite and anterior open bite. Approximately 31.4% of patients exhibited oral habits, with nail biting being most common. No significant gender differences were observed in the prevalence of oral habits. Oral habits were not significantly associated with malocclusion types except for anterior open bite, where 87.5% of affected patients exhibited habits. Consider the only significant relationship between oral habits and malocclusion type was observed between anterior open bite (AOB) where 87.5% of subjects who had AOB gave a positive history of oral habits.

Conclusion: This study highlights the prevalence of malocclusion, different malocclusion types, low diastema rates, and significant occurrences of increased overjet, overbite, and tooth rotations, emphasising the need for regional assessments to address the dental needs of the population.

ORIGINAL ARTICLE

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Introduction

Malocclusion refers to an irregularity concerning teeth alignment and/or their relationship during dental occlusion beyond the range of what is accepted as normal.[1] Malocclusion ranks amongst the top 3 oral pathologies and oral public health priorities.[2] Numerous etiological factors have been suggested for malocclusion, with genetics, environmental influences, and ethnic background being primary contributors.[3] Functional adaptations to environmental factors can impact surrounding structures, such as dentition, bone, and soft tissues, ultimately leading to various malocclusion issues. Consequently, malocclusion is considered a multifactorial condition without a single definitive cause.[4]

Several studies[4,5,6.] on malocclusion have reported varied findings across different populations worldwide.[7] There is clear evidence of ethnic variation in prevalence and types of malocclusion. As the demand for orthodontic treatment increases in many countries,[7] with data showing the negative impact of malocclusion on quality of life, understanding the patterns of common malocclusions in specific populations will aid orthodontic practitioners in planning effective treatment.

There is limited data regarding the pattern of malocclusion in Northern Nigeria. The aim of this study was to determine the types of malocclusion based on gender and age among orthodontic patients at Aminu Kano Teaching Hospital (AKTH), Kano, and to determine the pattern of distribution of the anterior posterior relationships of the jaws and the effects of oral habits on these malocclusion patterns. Furthermore, the data will be valuable for comparing the results of this study with findings reported in other populations.

Materials and methods

This descriptive retrospective study analysed data collected from pre-treatment records of patients seen between January 2019 to July 2024 at the Orthodontic Unit of the Child Dental Health Department, Aminu Kano Teaching Hospital (AKTH) in Kano, Records of a total of 106 patients aged 8 to 40 years were reviewed and collected.

The inclusion criteria for the study were as follows:

1. Patients who presented at the Orthodontic Unit of between January 2019 and July 2024 with compliant of malocclusion or related symptoms
2. Subjects who had complete pre-treatment records
3. Presence of first permanent molars and canines
4. No prior history of orthodontic treatment

The exclusion criteria were:

1. Patients with incomplete orthodontic records
2. Patients without first permanent molars or canines
3. Patients with significantly deteriorated first permanent molars

Demographic data (age and gender) and malocclusion type were recorded for each patient. Molar relationships were classified using Angle's classification of malocclusion into Class I, Class II, or Class III malocclusion. Overjet was measured in millimetres from the edge of the upper central incisor to the labial surface of the lower central incisor; 1–3 mm was considered normal, greater than 3 mm was classified as increased, and less than 1 mm was reduced. Overbite was also measured in millimetres as the perpendicular distance from the edge of the lower central incisor to the upper central incisor. A normal range was 0–3 mm; values above 3 mm indicated a deep bite, and values below 0 mm indicated an open bite.

Crowding in the upper and lower arches was measured in millimetres and categorised as follows: 0 mm (no crowding), 1–3 mm (mild crowding), 4–6 mm (moderate crowding), and 7 mm and above as severe crowding. A maxillary midline diastema was diagnosed when there was a space of at least 1 mm between the upper central incisors. Oral habits were noted as present or absent, with specific types documented.

Ethical clearance for the study was obtained from the institutional Health research and Ethics board of Aminu Kano Teaching Hospital.

Data was cleaned and processed in MS Excel and statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20, SPSS Inc., Chicago, IL, USA. (SPSS).

Results

Socio-demographic data of the study participants

The orthodontic patient population at the Aminu Kano Teaching Hospital, Kano, Nigeria, over the 5-year period from 2019 to 2024, comprised 106 patients. Female patients outnumbered their male counterparts, accounting for 65.7% of the total patient population (Table 1). The age range of these patients spanned from 8 to 40 years, with a mean age of 14.5 ± 5.6 years. The largest proportion of patients (40%) fell within the 11-15 years age bracket. This was followed by the <10 years age group, which accounted for 26.7% of the patients. The remaining age groups had smaller proportions, with the oldest age group (>25 years) comprising only 5.7% of the patients.

Table 1. Age and sex distribution of orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Sex	n (%)	Range	Mean ± SD	P-value
Female	69 (65.7)	7 – 40	14.7 ± 5.6	0.72
Male	36 (34.3)	8 – 32	14.3 ± 5.6	
Total	105 (100)	7 – 40	14.5 ± 5.6	

P-value estimated using Independent t-test

A comparison of age group distribution by sex (Figure 1) indicates that female patients were more prevalent in the younger age groups, while the proportions of male and female patients were more evenly distributed in the older age groups. However, there was no statistically significant difference in the mean age between male and female patients (p = 0.72).

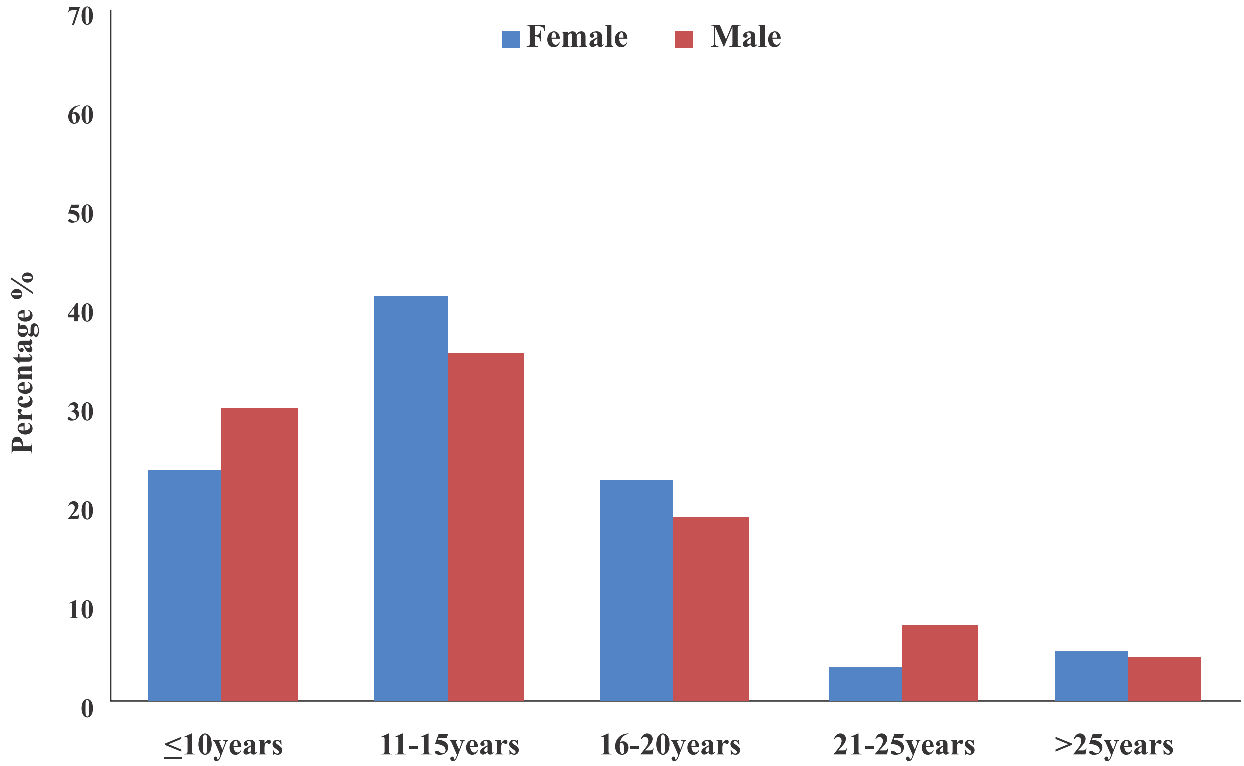

Figure 1. Age group distribution by sex among orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Overall prevalence and distribution pattern

Table 2 summarises the pattern of malocclusion among orthodontic patients treated at the Aminu Kano Teaching Hospital, Kano, Nigeria, between 2019 and 2024. Based on Angle's Classification of Malocclusion, the majority of patients (64.4%) exhibited Class I malocclusion, followed by Class II (29.8%) and Class III (5.8%) malocclusions.

The prevalence of diastema, defined as spacing between the teeth of more than 1mm was low, with 89.5% of patients having a diastema of 0 to 1 mm. Overjet was recorded in 51.4% of patients, with 44.8% having an overjet of 0 to 4 mm. Regarding overbite, 50.5% of patients had an overbite of 2 to 3 mm, while 45.7% exhibited an overbite of 4 mm or more. Crossbite was present in 16.2% of patients. Additional findings revealed that 7.6% of patients had an anterior open bite, and 69.2% showed tooth rotations (Table 2).

Table 2. Pattern of malocclusion among orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Malocclusion	Frequency, n	Percentage, %	95% CI
Angle's Class			
Class I	67	64.4	54.8 – 73.0
Class II	31	29.8	21.0 – 39.2
Diastema			
<1 mm	94	89.5	82.0 – 94.6
>1 mm	11	10.5	5.3 – 18.0
Overjet			
0 – 4 mm	47	44.8	35.0 – 54.8
>4 mm	54	51.4	41.5 – 61.3
Reverse	4	3.8	1.0 – 9.5
Overbite			
0 – 1 mm	4	3.8	1.0 – 9.5
2 – 3 mm	53	50.5	40.5 – 60.4
≥4 mm	48	45.7	35.9 – 55.7
Crossbite			
Absent	88	83.8	75.3 – 90.3
Present	17	16.2	97.2 – 24.6
Anterior Open Bite			
Absent	97	92.4	85.5 – 96.7
Present	8	7.6	33.5 – 14.5
Rotations			
Absent	32	30.8	21.9 – 40.2
Present	72	69.2	58.8 – 77.3

Distribution of malocclusion according to gender and age

The distribution of malocclusion in the study population was analysed by sex and age groups (Tables 3 and 4). There was no statistically significant difference in the distribution of Angle's Classification, diastema, overjet, overbite, crossbite, anterior open bite, and rotations between male and female patients.

In contrast, analysis by age groups revealed notable differences. The highest proportion of Angle's Class I malocclusion was observed in the <10 years (75%)

and >25 years (83.3%) age groups. Conversely, Class III malocclusion was more prevalent in the 16–20 and 21–25 age groups (17.4% and 16.7%, respectively, p = 0.06).

Additionally, younger age groups (<10 years and 11–15 years) had a significantly higher proportion of increased overbite (≥4 mm) compared to older age groups (p = 0.003). The analysis also revealed a significant association between age and anterior open bite (p = 0.05), with the prevalence of anterior open bite being highest among older age groups: 33.3% in patients aged 21–25 years and 16.7% in those above 25 years.

Table 3. Pattern of Malocclusion according to gender and age among orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Malocclusion	Sex, n (%) Female (n = 68).	Male (n = 36)	Age (years), n (%) <10 (n = 28)	11 – 15 (n = 42)	16 – 20 (n = 23)	21 – 25 (n = 6)	>25 (n = 6)
Angle's Class							
Class I	43(63.2).	24 (66.7)	21(75.0)	28(68.3)	11(47.8)	2(33.3)	5(83.3)
Class II.	21(30.9).	10 (21.8)	6(21.4)	13(31.7)	8(34.8)	3(50.0)	1(16.7)
Class III	4(5.9)	2 (5.6)	1(3.6)	0	4(17.4)	1(16.7)	0
	p = 0.94			*p* = 0.06			
Diastema							
<1mm	63(91.3)	31(86.1)	24(58.7)	37(88.1)	23(100)	5(83.3)	5(83.3)
>1mm	6(8.7)	5(13.9)	4(14.3)	5(11.9)	0	1(16.7)	1(16.7)
	p = 0.41			*p* = 0.23			
Overjet							
0 – 4 mm	30 (43.5)	17(47.2)	15(53.6)	16(38.1)	9(39.1)	4(66.7)	3(50.0)
> 4 mm.	37(53.6)	17(47.2)	12(42.9)	25(59.5)	12(52.2)	2(33.3)	3(50.0)
Reverse	2 (2.9)	2(5.6)	1(3.6)	1(2.4)	2(8.7)	0	0
	p = 0.66			*p* = 0.73			

P-value estimated using Chi-square test and Fisher's exact test

Table 4. (Continuation) Pattern of malocclusion according gender and age among orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Malocclusion	Sex, n (%) Female (n = 68).	Male (n = 36)	Age (years), n (%) <10 (n = 28)	11 – 15 (n = 42)	16 – 20 (n = 23)	21 – 25 (n = 6)	>25 (n = 6)
Overbite							
0 – 1 mm	2 (2.9)	2 (5.6)	0	0	4 (17.4)	0	0
2 – 3 mm	33 (47.8)	20 (55.6)	19 (67.9)	14 (33.3)	12 (52.2)	4 (66.7)	4 (66.7)
≥ 4 mm	34 (49.3)	14 (38.9)	9 (32.1)	28 (66.7)	7 (30.4)	2 (33.3)	2 (33.3)
		p = 0.50		*p* = 0.003			

Table 4. (Continuation) Pattern of malocclusion according gender and age among orthodontic Patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024) (contd)

Malocclusion	Sex, n (%) Female (n = 68).	Male (n = 36)	Age (years), n (%) <10 (n = 28)	11 – 15 (n = 42)	16 – 20 (n = 23)	21 – 25 (n = 6)	>25 (n = 6)
Crossbite							
Absent	58 (84.1)	30 (83.3)	22 (78.6)	37 (88.1)	18 (78.3)	6 (100)	5 (83.3)
Present	11 (15.9)	6 (16.7)	6 (21.4)	5 (11.9)	5 (21.7)	0	1 (16.7)
		p = 0.92		*p* = 0.62			
Anterior Open Bite							
Absent	64 (92.7)	33 (91.7)	27 (96.4)	38 (90.5)	23 (100)	4 (66.7)	5 (83.3)
Present	5 (7.2)	3 (8.3)	1 (3.6)	4 (9.5)	0	(33.3)	1 (16.7)
		p = 1.00		*p* = 0.05			
Rotations							
Absent	23 (33.3)	9 (25.7)	10 (37.0)	11 (26.2)	8 (34.8)	2 (33.3)	1 (16.7)
Present	46 (66.7)	26 (74.3)	17 (63.0)	31 (73.8)	15 (65.2)	4 (66.7)	5 (83.3)
		p = 0.43		*p* = 0.81			

P-value estimated using Chi-square test and Fisher's exact test

Prevalence of Oral Habits

Table 5 presents the prevalence and distribution of oral habits among the study population. Approximately one-third of the patients (31.4%) exhibited at least one oral habit. The most common habit was nail biting, observed in 33.3% of patients with oral habits (Figure 2). Tongue thrusting and lip biting were also frequent, each affecting 18.2% of patients. Other habits, such as thumb sucking, mouth breathing, and teeth gnashing, were less prevalent.

When analysed by gender, oral habits were found in 27.5% of female patients and 38.9% of male patients. However, this difference was not statistically significant (p = 0.23), indicating a comparable prevalence of oral habits between male and female patients.

Table 5. Prevalence and distribution of oral habits by gender

Gender	N	Oral Habit, n (%) Absent	Present	95% CI of Prevalence	P-value
Female	69	50 (72.5)	19 (27.5)	17.5 – 39.6	0.23
Male	36	22 (61.1)	14 (38.9)	23.1 – 56.5	
Overall	105	72 (68.6)	33 (31.4)	22.7 – 41.2	

P-value estimated using Chi-square test

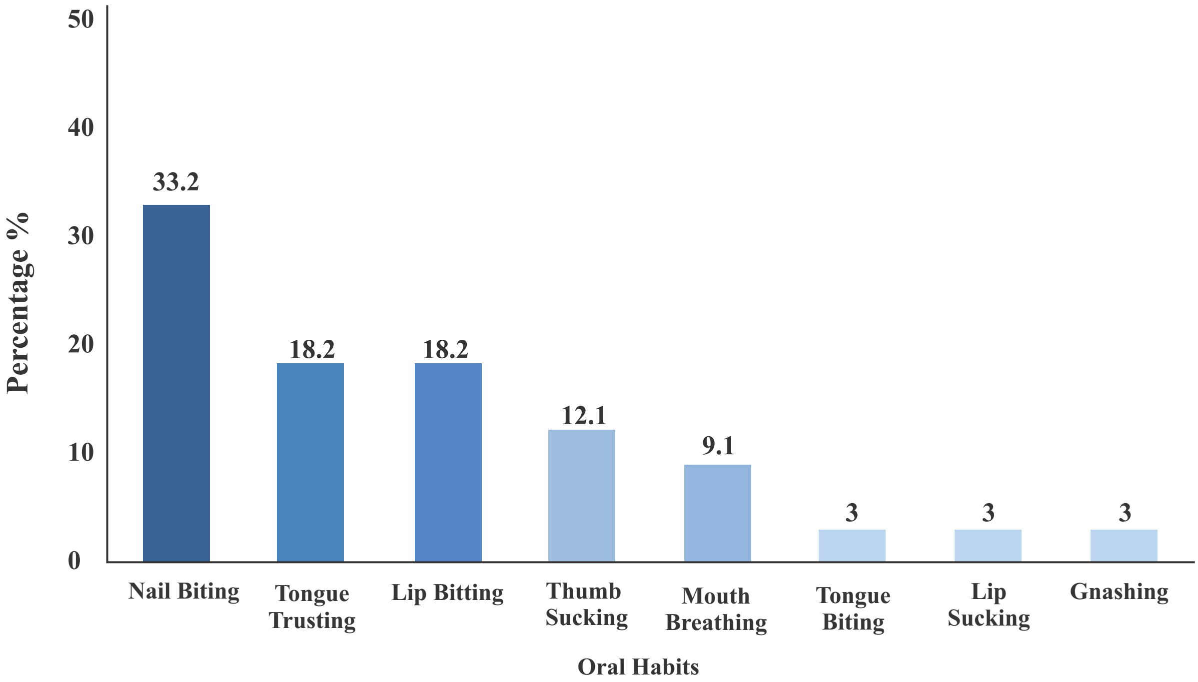

Figure 2. Type of oral habit among orthodontic patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Association Between the Presence of Oral Habits and Malocclusion

Table 6 illustrates the association between oral habits and malocclusion. The findings indicate that oral habits were not significantly associated with Angle's Classification ($p = 0.37$), overjet ($p = 0.21$), overbite ($p = 0.21$), or crossbite ($p = 0.44$).

However, a marginally significant association was observed between oral habits and diastema ($p = 0.10$). Over half (54.5%) of patients with a larger diastema (2–4 mm) exhibited an oral habit, compared to 28.7% of patients with normal spacing (0–1 mm).

The only significant association identified was between oral habits and anterior open bite ($p < 0.001$). A striking 87.5% of patients with anterior open bite had an oral habit, compared to 26.8% of those without anterior open bite.

Table 6. Association between the presence of oral habits and malocclusion among orthodontic Patients at the Aminu Kano Teaching Hospital, Kano (2019 – 2024)

Malocclusion	N	Oral Habit, n (%) Absent	Present	P-value
Angle's Class				
Class I	67	43 (64.2)	24 (35.8)	0.37
Class II	31	24 (77.4)	7 (22.6)	
Class III	6	5 (83.3)	1 (16.7)	
Diastema				
< 1mm	94	67 (71.3)	27 (28.7)	0.10
> 1mm	11	5 (45.4)	6 (54.5)	

Overjet				
0 – 4 mm	47	28 (59.6)	19 (40.4)	0.21
> 4 mm	54	41 (75.9)	13 (24.1)	
Reverse	4	3 (75.1)	1 (25.0)	
Overbite				
0 – 1 mm	4	3 (75.0)	1 (25.0)	0.21
2 – 3 mm	53	32 (60.4)	21 (39.6)	
≥ 4 mm	48	37 (77.1)	11 (22.9)	
Crossbite				
Absent	88	59 (67.0)	29 (32.9)	0.44
Present	17	13 (76.5)	4 (23.5)	
Anterior Open Bite				
Absent	97	71 (73.2)	26 (26.8)	< 0.001
Present	8	1 (12.5)	7 (87.5)	
Rotations				
Absent	32	22 (68.7)	10 (31.2)	0.94
Present	72	50 (69.4)	22 (30.6)	

P-value estimated using Chi-square test and Fisher's exact test

Discussion

The pattern of malocclusion varies globally, regionally, and even between cities.[8] Evaluating orthodontic patients provides valuable insights for planning treatment and assessing malocclusion distribution. Understanding these patterns is essential for guiding treatment priorities and developing effective orthodontic services and preventive programs tailored to specific populations.[9]

The majority of participants in this study were female, a finding consistent with previous studies,[10,11] indicating that women are more likely to seek orthodontic treatment. This trend can be attributed to the greater emphasis that females typically place on dental aesthetics and appearance, compared to males. Social and cultural factors may also play a role, as women are often subjected to societal expectations regarding physical appearance, which can influence their health-seeking behaviours, including pursuing treatments to enhance their smiles. Additionally, studies[12,13] have suggested that females may have a higher level of self-awareness and concern about oral health, contributing to their proactive approach toward orthodontic care.

Angle's Class I malocclusion was the most prevalent pattern observed in 64.4% of participants who sought treatment at the Orthodontic Unit of the Child Dental Health Department, Aminu Kano Teaching Hospital. This finding is consistent with studies conducted in the southern regions of Nigeria,[10,14-16] other African countries,[3,17] and globally.[1,5] The global prevalence of Angles class 1 Malocclusion could be related to the wide range of malocclusion traits within this class.

In this study, Angle's Class II malocclusion was observed in 29.8% of participants, a value comparable to the findings reported by Borzabadi-Farahani *et al*.[18] among urban Iranian adolescents but lower than those reported by Guclipaneni *et al*.[19] among Saudi adolescents. Class II malocclusion has been found to be the most common pattern among individuals of Northern European descent[20] and Pakistani[21] populations. The proportion of subjects with Angles Class II malocclusion in our study was higher than reported in some studies from Southern Nigeria,[6,14,22] but similar to results from another study in Lagos, Nigeria.[11] Angle's Class III malocclusion was the least common in this study, found in 5.8% of participants. This is higher than the findings reported by Ajayi[22] (1.8%) among schoolchildren in Benin City and Obanubi *et al*.[11] (4.1%) among patients at the Lagos State University Teaching Hospital. However, it is lower than findings by Onyeaso *et al*.[6] (8.0%) at the University College Hospital Ibadan and Folaranmi and Okeke.[10] (24.3%) at the University of Nigeria Teaching Hospital, Enugu. The variations in malocclusion patterns across studies may be attributed to differences in sample selection techniques, the diversity of local ethnic groups, and cultural practices. Overall the relatively low frequency of Class III malocclusion aligns with craniofacial norms reported in sub Saharan Africa.

Overall, the findings from this study is similar with the studies reported in other parts of Nigeria,[9,10] Africa,[3,17] and globally,[1,5] where Class I malocclusion remains the most common, followed by Class II and Class III malocclusions. These results provide valuable insights for orthodontic practitioners to develop targeted treatment strategies tailored to the specific needs of different populations.

In the present study, 74.3% of participants had Skeletal Class I pattern, indicating a normal skeletal relationship between the upper and lower jaws. Skeletal Class II and Class III patterns were observed in 19.0% and 6.7% of patients, respectively.

The present study also found a low prevalence of diastema, (space greater than 1mm) in *10.5%,* contrasting with higher rates reported in studies from the South-Southern[22] and South-Western[6] regions of Nigeria. The variations noticed in diastema prevalence may be attributed to differences in demographics, age groups, and cultural or genetic factors. Our study recorded high values of both overjet and overbite, with overjet being more prevalent than overbite. These findings differ from studies conducted in the southern regions of Nigeria and among Tanzanian children,[23] where higher occurrences of normal overjet and overbite were reported. The variations in findings may be partially attributed to differences in the criteria used to define increased overjet in various studies. Discrepancies in sample selection, measurement techniques, and population demographics could also contribute to these differences. In this study, crossbite was observed in 16.2% of participants, a prevalence higher than the values reported by Ajayi [22] (11.5%) and Onyeaso *et al*.[6] (12.8%). However, it was lower compared to the findings by Otuyemi *et al*.[24] (17.8%) and Utomi *et al*.[25] (20.4%).

Furthermore, the study revealed that 7.6% of patients had an anterior open bite, a value comparable to the 7.1% reported by Aikins and Onyeaso in Rivers State.[15] However, it was higher than the values reported by Ajayi[21] (4.1%) in Benin and Gudipaneni *et al*.[19] (4.6%) among Saudi subjects. Anterior open bite is clinically significant due to its impact on aesthetics, speech, and biting efficiency. Additionally, 69.2% of the participants exhibited tooth rotations. The high prevalence of tooth rotations emphasises the need for corrective interventions to improve occlusion, dental hygiene, and overall smile aesthetics.

This study found no significant association between malocclusion patterns and participants' age or gender, consistent with findings from Obanubi *et al*.[11] and Kashif *et al*.[26] However, a higher prevalence (75%) of Angle's Class I malocclusion was observed among participants under 10 years compared to older age groups. This difference may be attributed to parental influence or peer pressure, as younger children are more likely to receive treatment at the recommendation of their parents or caregivers.

These results highlight the importance of regional assessments to inform tailored orthodontic treatment strategies. In addition, given the limited resources for healthcare provision, tailored preventive strategies may be developed along these identified areas. These differences could be attributed to differences in sample size, age distribution, regional factors, and diagnostic criteria used in each study. Environmental factors, dietary habits, and genetic variations could also play a role in influencing the development of crossbite in different populations.

Conclusion

This study provides important insights into malocclusion patterns among orthodontic patients at Aminu Kano Teaching Hospital, Kano, Nigeria. Angle's Class I malocclusion was the most prevalent, followed by Class II and Class III, aligning with regional and global trends. Diastema was uncommon, but there were notable occurrences of overjet, overbite, crossbite, and tooth rotations, emphasising the need for corrective interventions. Furthermore, 7.6% of patients exhibited anterior open bite, a condition with significant implications for aesthetics and oral functionality. While no significant relationship was found between malocclusion patterns and age or gender, Class I malocclusion was more prevalent among participants under 10 years. These findings underscore the importance of regional assessments and tailored orthodontic strategies to address the specific dental needs of the population.

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Conflict of Interest - None to declare

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The Role of Artificial Intelligence in Orthodontics

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Abstract
Artificial Intelligence (AI) has rapidly emerged as a transformative tool in orthodontics, enhancing diagnostic accuracy, treatment planning, and clinical workflows. From its early conceptualisation to its present integration into healthcare, AI now plays a pivotal role in optimising orthodontic outcomes through data-driven decision-making and automation. This review synthesises current literature on the applications, benefits, and limitations of AI in orthodontics. It explores AI paradigms, including symbolic AI, machine learning, and deep learning, while categorising their functionalities into classification, regression, detection, and segmentation. Key databases and recent studies were evaluated to gather relevant data and outcomes across multiple subdomains of orthodontic practice. AI has been effectively implemented in diverse orthodontic tasks such as cephalometric analysis, bone age prediction, airway assessment, facial proportion analysis, and appliance fabrication. AI-assisted systems have demonstrated high accuracy (often >90%) in diagnosis, treatment planning, and prediction models. Notably, applications like extraction decision support, impacted canine management, and orthognathic surgery planning have shown significant promise. The integration of AI with teleorthodontics and 3D printing also opens new avenues for remote and customised care. AI is reshaping orthodontic practice by improving precision, efficiency, and patient outcomes. While challenges such as data bias, privacy concerns, and regulatory gaps remain, ongoing innovations suggest a future where AI could democratise access to advanced orthodontic care, especially in underserved regions. Strategic implementation and ethical governance will be key to its successful integration into routine practice.

ORIGINAL ARTICLE

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Introduction

Artificial Intelligence (AI), a term first introduced in 1955 by John McCarthy, describes the ability of machines to perform tasks that are classified as intelligent.[1,2] It is the simulation of human intelligence in machines, enabling them to learn, reason, and make decisions with minimal human input.[2,8] AI systems can analyse vast amounts of data, recognise patterns, and make decisions with minimal human intervention, improving efficiency and automation in various fields.[3]. In orthodontics, AI enhances diagnostic accuracy, treatment planning, and overall patient care by analysing large datasets, recognising patterns, and predicting outcomes with minimal human intervention.[8]

Paradigms of AI in Orthodontics

1. Symbolic AI (GOFAI): Symbolic AI, also referred to as "good old-fashioned AI" (GOFAI) which was popular until the late 1980s, uses rules, such that when a certain criterion is met, a corresponding action must be taken.[6] Rule-based systems using "if-then" logic.[6]

2. Machine Learning (ML)[4]: Machine learning is a term first phrased by Arthur Samuel in 1952.[5] In machine learning (ML), algorithms are classified according to the kind of learning and the desired

result. There are three main categories: [4] Supervised learning: Supervised learning is a procedure used in orthodontic decision-making, such as extraction planning, where predictions or classifications are guided by known outcomes.[4] In supervised learning the output data is known in advance and this helps AI to be able to make precise predictions about a newly input data.[8] Unsupervised learning: In orthodontics, unsupervised learning arranges data without labels, exposing patterns or connections. It helps with tasks that do not have defined results, making analyses and classifications easier. [4,8,13]

Reinforced learning: Reinforced learning helps systems improve by learning through trial and error using feedback, without prior knowledge. In orthodontics, this approach enhances efficiency by enabling systems to learn from mistakes and refine their methods over time.[4]

3. Deep Learning (DL): Deep learning (DL) is a branch of machine learning that automatically extracts features from raw data. It uses artificial neural networks (ANNs), developed in the 1990s.[5] With better computing power, deeper and more complex networks have been created. These "deep" networks can solve more advanced problems. DL reduces the need for manual input. It learns patterns from data on its own. This makes it useful in areas like image analysis and healthcare.[5] As a subset of machine learning, deep learning uses neural networks and has excelled in processing complex data structures, particularly high-dimensional data such as images.[7,10]

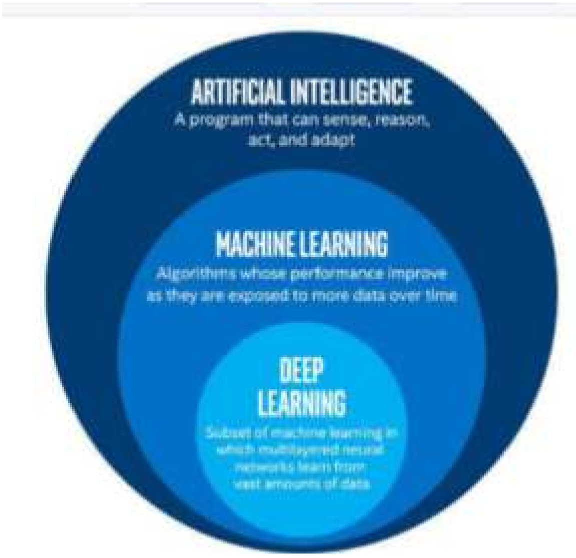

Figure 1: Shows a simplified AI diagram, which shows machine learning as a paradigm of artificial intelligence and deep learning, a subset of machine learning.

Four AI driven tasks

The 4 major AI-driven tasks in dentistry are :

1. Classification 2. Regression
3. Detection, and 4. Segmentation

(1) Classification is the most known AI-driven task and it assigns objects to categories that have been pre-specified or pre-labeled.[9] Examples include; support vector machine (SVM), decision trees and many more.[9] (2) Regression analysis is a statistical and machine learning method used to identify relationships between variables and predict continuous outcomes. For example, it can estimate a patient's age based on tooth wear or bone density by finding patterns in the data.[9] (3) Object detection focuses on determining the location of objects within

an image or video. Unlike basic image classification, which merely identifies the presence of objects, detection goes a step further by pinpointing their exact positions. A widely used method for object detection is the Region-based Convolutional Neural Network (R-CNN), which involves generating region proposals, extracting features using a CNN, and classifying each proposed region.[9] (4) In dentistry, object segmentation involves pixel-level classification to distinguish different structures within a region of interest.[9] This technique helps divide dental images into components like teeth, gums, bones, and lesions, aiding diagnosis and treatment planning. In orthodontics, for instance, it allows individual teeth to be isolated for alignment assessment and appliance design.

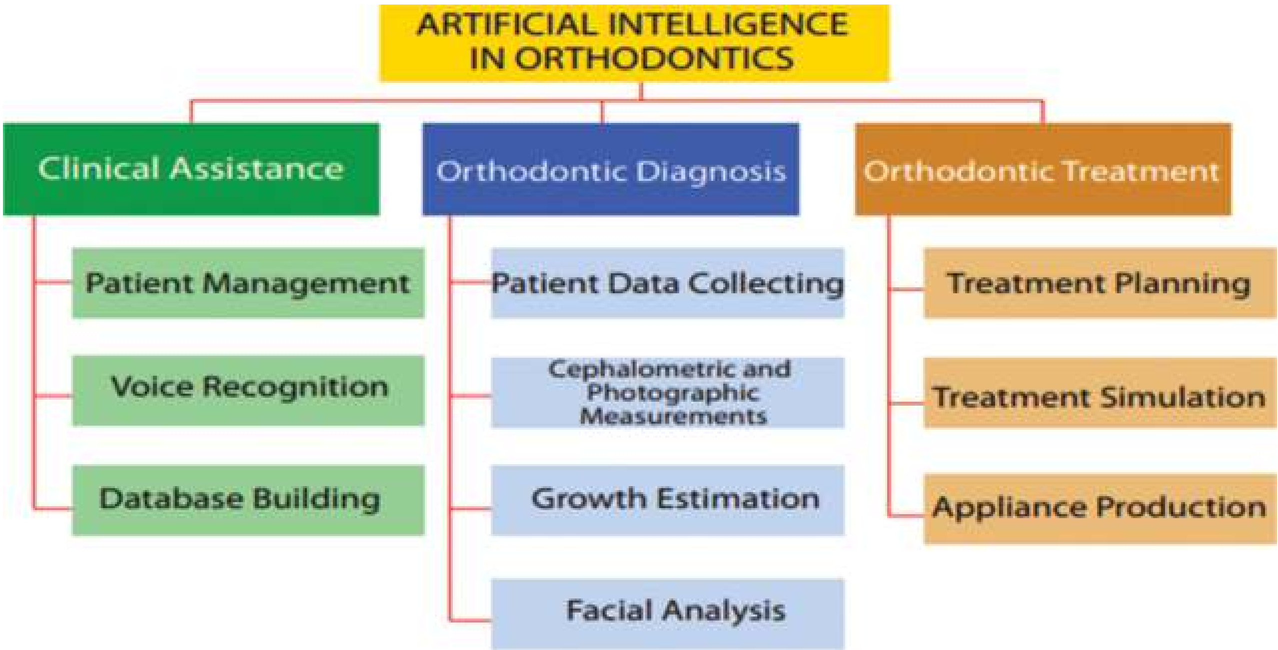

Figure 2: Key Applications of AI in Orthodontics

Diagnosis and Treatment Planning

The area of orthodontic diagnosis and treatment planning is changing as a result of the integration of artificial intelligence which gives better accuracy and efficiency.[4] Machine learning and computer vision have made it easy for AI to automate complex patient evaluations and this gives orthodontists access to a wide range of cephalometric analytic tools.[4] A study by Ezhov (2021) compared AI-assisted and unaided dentists in oral CBCT evaluations. The AI system improved diagnostic performance, with higher sensitivity (0.8537 vs. 0.7672) and specificity (0.9672 vs. 0.9616) in the AI-aided group.[6] Systematic reviews and meta-analyses on AI for detecting caries and periapical lesions have shown varying accuracy (68%–99.2%) depending on imaging methods.[6] A 2019 meta-analysis reported 88.75% accuracy for AI in detecting radiolucent lesions, while a 2023 study aby Sadr found AI had high sensitivity (0.925) and specificity (0.852).[6] These findings suggest AI can serve as an effective diagnostic aid in diagnosis and treatment planning.[6] Due to the ability of AI, machine language, computer vision and natural language processing combined simplify patient diagnosis and treatment planning.[4]

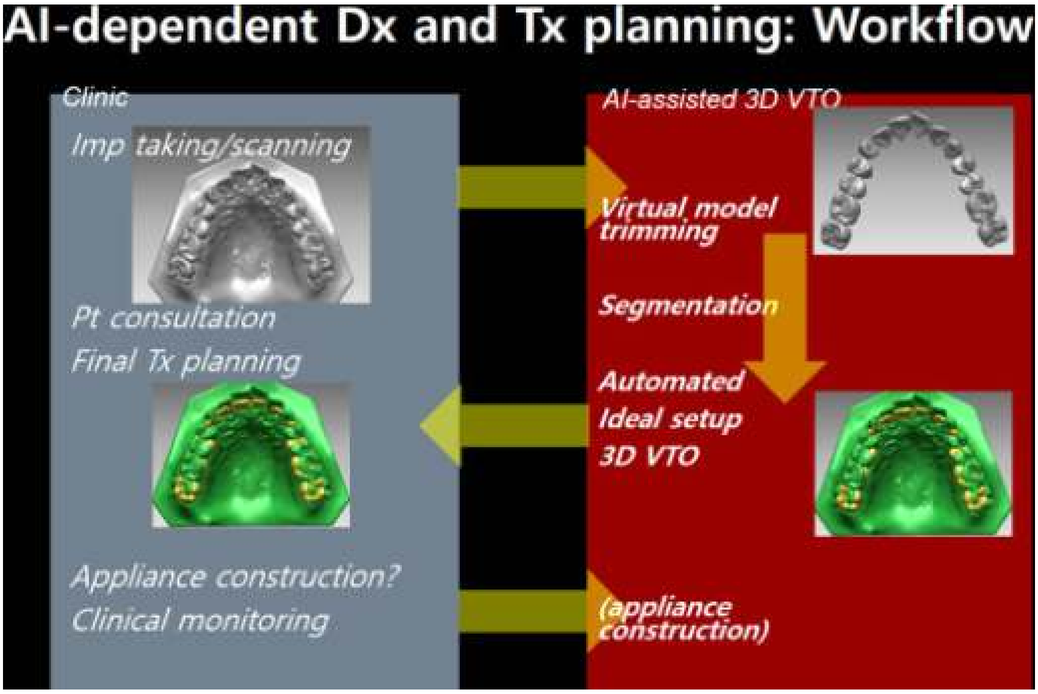

Figure 3: It shows AI depends diagnosis and treatment planning workflow

Bone Age Prediction

The choice of proper treatment timing depends on bone age prediction based on cervical vertebrae maturity, and this is very vital because it directly impacts the effectiveness of orthodontic treatments.[6] The Machine Learning-based methods, which include the convolutional neural networks, according to Seo et al. (2021), have shown >90% accuracy for vertical and sagittal skeletal maturation diagnosis.[6] In orthodontics, classification models have shown greater accuracy than clustering methods for predicting bone age. Among various classifiers, the artificial neural network (ANN) achieved the highest performance, with a weighted kappa of 0.926, indicating its effectiveness in determining cervical vertebral maturation.[10]

Airway Obstruction Assessment

There is a reciprocal relationship between skeletal deformities and airway obstruction. Impaired airflow, such as that caused by upper-airway obstruction, can influence breathing patterns and disrupt normal craniofacial growth, potentially resulting in malocclusion and other facial irregularities. Therefore, identifying conditions like adenoid hypertrophy is essential for accurate orthodontic assessment and effective treatment planning.[11] In light of this, Dong et al. introduced two deep learning models—hierarchical masks self-attention U-net (HMSAU-Net) for upper airway segmentation and 3D-ResNet for diagnosing adenoid hypertrophy from CBCT scans. The 3D-ResNet10 model demonstrated a high accuracy of 0.912 in diagnosing adenoid hypertrophy.[12]

Landmark Identification and Cephalometry Tracing

The use of artificial intelligence (AI) in identifying anatomical landmarks on radiographs has enhanced orthodontic diagnosis and treatment planning.[4] In order to advance cephalometric analysis, Montúfar et al. (2018) introduced a hybrid approach that automates the annotation of anatomical landmarks in cephalometric images.[18] This method integrates artificial intelligence (AI) algorithms with dynamic shape models, allowing for more accurate and efficient identification of key landmarks, thus streamlining the process of cephalometric analysis.[4] In addition, Montúfar et al. (2018) developed an AI-driven system for automatic 3D cephalometric landmark identification, aimed at simplifying the analysis of craniofacial changes in response to orthodontic therapy.[18]

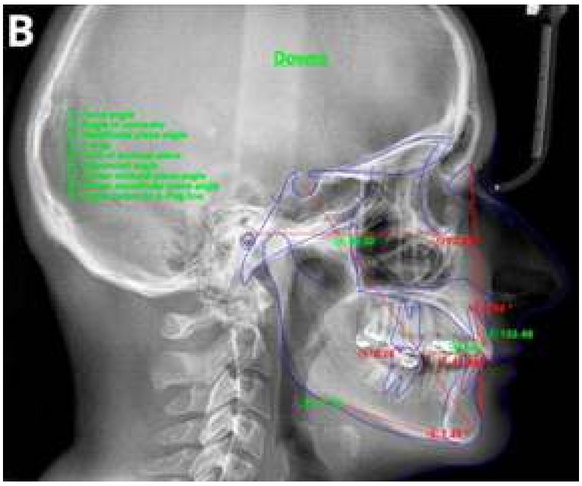

Figure 4: Shows a sample of automatic cephalometric landmark tracings performed using WebCeph. It shows that the results of Downs cephalometric analysis are superimposed on the tracing and measurements outside the standard range marked in red with asterisks.

Growth and Development Estimation

Evaluating growth and development indicators is vital for properly timing orthodontic treatment. Key markers like skeletal maturity, physical height, and chronological age play a significant role in orthodontic diagnosis and planning.[4] Kök et al. (2019) reported that among seven different AI approaches used to evaluate cervical vertebral maturation, Artificial Neural Networks (ANN) demonstrated the highest performance.[17] By mimicking the structure and function of the human nervous system, Artificial Intelligence (AI) significantly enhances both the precision and speed of analyzing growth and skeletal maturity indicators in orthodontics.[4]

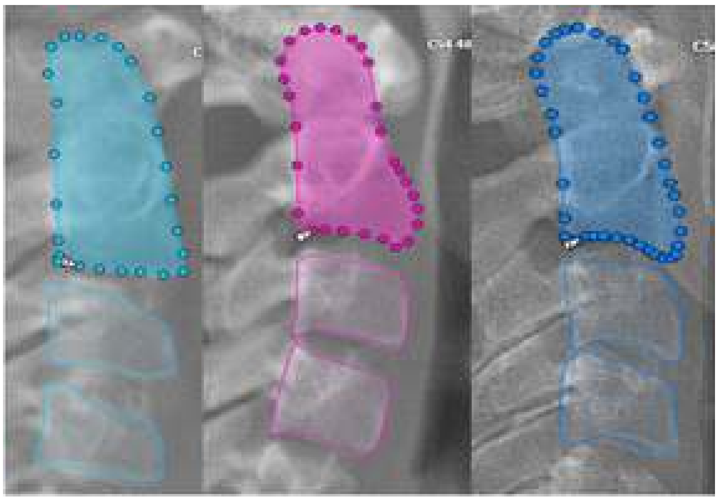

Figure 4: It shows an artificial intelligence-based algorithm for cervical vertebrae maturation stage assessment where AI algorithms are used to automatically identify and outline cervical vertebrae (C2–C4) on lateral cephalometric radiographs. By analyzing the shape and size of these bones, the AI accurately determines the patient's skeletal maturation stage, helping orthodontists plan growth-related treatments more objectively and efficiently.

Facial Proportion Analysis

Ai is revolutionising facial proportion assessment by using optical facial recognition, in contrast to traditional method relying on profile photographs and lateral cephalometric radiographs.[19] By surpassing the limitations of traditional dimensional analysis, artificial intelligence (AI) enables the assessment of angular measurements and facial ratios. AI offers objective evaluations of facial aesthetics by incorporating various beauty parameters, potentially enhancing orthodontic and surgical decision-making through a deeper understanding of facial attractiveness.[4]

Extraction Prediction:

Xie et al. created an expert system (ES) using artificial neural networks (ANN) that achieved 80% accuracy. This was done in order to determine whether extraction is needed for management of malocclusion in patients between the ages of 11 and 15.[21] Jung et al. used artificial neural networks (ANN) to forecast extraction patterns with 84% accuracy.[20] Artificial intelligence (AI) technologies simulate human decision-making, achieving 80-90% accuracy in orthodontic extraction decisions. These technologies particularly assist orthodontists with less experience, offering guidance that enhances decision-making. AI algorithms not only optimise treatment outcomes but also reduce human error, streamline processes, and help tailor orthodontic interventions to individual patient needs, improving overall efficiency in clinical practice.[4]

Management of Impacted Canines

AI-assisted Radiographic Analysis: Deep learning models analyse panoramic and CBCT (Cone Beam Computed Tomography) images to detect impacted canines early, even before they become clinically evident.[22] A study by Kumar et al. demonstrated that CNN successfully detects impacted and non impacted maxillary canines on cropped and uncropped Panoramic radiographs.[22]

AI helps in identifying dental and skeletal landmarks, improving accuracy in localizing impacted canines. AI models simulate the likely eruption path of impacted canines. It involves the utilisation of CBCT to enhance early diagnosis and interception of canine impactions and this addresses the limitations found in traditional 2D radiographs.[23] Virtual Surgical Planning (VSP): AI assists in planning surgical exposure of impacted canines, optimizing flap design and minimizing complications.[24] AI significantly improves precision, speed, and reliability in the management of impacted canines in orthodontics. It aids in early identification, treatment strategy, and follow-up care, leading to fewer mistakes and better patient results.[25]

Treatment Outcome Assessment

Traditional multi-regression models analyse dental treatment outcomes but are limited by their linear assumptions and inability to capture all possible results.[4] Artificial neural networks overcome these limitations by modeling complex, non-linear relationships, especially in orthodontic cases like Class II and III malocclusions, further enhanced by the digital clear aligner technology introduced in 1997.[4]

Appliance Fabrication

AI-driven 3D scanning and CAD/CAM technology create custom-fitted orthodontic appliances (e.g., clear aligners). The development of digital clear aligner devices has made it easier to simulate orthodontic treatment, since manual methods made this procedure more difficult.[27] AI-generated data is fed into CAD (Computer-Aided Design) software to create digital models of braces, aligners, or retainers. CAD designs are then sent to CAM (Computer-Aided Manufacturing) systems, which use 3D printing or milling machines to create the appliance.[27] In 1946, Dr. Kesling introduced a removable plastic orthodontic appliance designed to make minor tooth movements—an innovation that laid the foundation for modern clear aligner therapy. Decades later, this concept evolved into a transformative orthodontic solution with the introduction of the Invisalign system by Align Technology in 1998.[26]

Orthognathic Surgery Planning

AI models, especially those using facial images and key measurements, are increasingly used to support orthognathic surgery decisions by improving diagnostic accuracy and offering guidance, though challenges like feature selection and overfitting remain.[9] AI is transforming orthognathic surgery by automating diagnostics, improving the accuracy of treatment planning, and enhancing surgical outcomes through tools like 3D simulations and machine learning-based decision systems.[8]

Cleft Lip and Palate (CLP)

The clinical application of AI in diagnosis and treatment planning of cleft patients can be seen from different aspects. Diagnosis and Prediction: Some studies used AI in identifying clefts and morphologic features in individuals with CLP. In this diagnosis ultrasound images can be used prenatally.[14] Agarwal et al. used AI in the identification of digital camera images through Support Vector machine (SVM) with a previously trained convolutional neural network. This combination identified images of individuals with clefts from normal, and differentiated between unilateral and bilateral.[14]

Pre-surgical Orthopaedics: Sequential plates for infants with cleft lip and palate who required naso-alveolar moulding (NAM) was developed using AI. Moulding of foetal tissues was done, taking into account the growth of the maxillary arch using AI. A sequence of plates for NAM was generated, and this can be 3D-printed and delivered.[14] In a study conducted among healthy control and non-syndromic cleft lip and palate infants (NSCL/P), machine learning algorithms were used in detecting defective variants in two genes necessary in folic acid and Vitamin A biosynthesis (methylenetetrahydrofolate reductase (MTHFR) and retinol-binding protein 4 (RBP4) genes).[14] A study by Machado et al. on the Brazilian population for NSCL±P revealed interactions among 13 SNPs as well as defects in genes involved in folate metabolism.[14,29]

Tele-orthodontics

Artificial intelligence (AI) has significantly advanced orthodontic remote monitoring by enhancing diagnosis, treatment planning, and patient follow-up. Systems like Dental Monitoring and Grin use AI-driven platforms to track oral hygiene, aligner progress, and treatment outcomes through patient-generated images and videos, reducing the need for in-office visits and improving efficiency[30]. Complementing this, AI integration into telehealth systems, as demonstrated by Thurzo et al., has enabled real-time monitoring, early issue detection, and tailored interventions, improving patient compliance and allowing clinicians to manage more cases with personalised care[4].

Benefits of AI in Orthodontics

- Faster and more accurate diagnoses
- Improved treatment planning
-Enhanced workflow and clinical efficiency
- Teleorthodontic capabilities
- Better patient experience and engagement
- Higher treatment success rates
- Significant time savings

Challenges and Limitations ([4],[8],[28],[9])

- Data bias and quality issues
- High initial setup costs
- Lack of standardization and regulation
- Limited human oversight and ethical concerns
- Patient privacy and data security risks
- Resistance to change among practitioners
- Inaccuracy in complex or non-standard cases

Possibilities of Integration of AI in Underserved Countries

1. Fully Automated Diagnosis: Advanced AI models will be able to detect malocclusions, assess skeletal structures, and generate instant treatment plans with minimal human intervention. AI will integrate with CBCT, intraoral scanners, and panoramic X-rays to provide real-time orthodontic analysis. Automated detection of orthodontic treatment needs like the index of orthodontic treatment need (IOTN) and index of orthognathic functional treatment need (IOFTN) would also be investigated.

2. 3D Printing Integration: AI will design and 3D-print fully customised clear aligners, braces, and orthodontic devices in real time. Machine learning algorithms will optimise instant tooth movement predictions, making treatments faster and more efficient. Patients may soon receive on-demand, in-office aligners without needing external manufacturers.

3. Smart Braces: AI-integrated smart braces will monitor tooth movement and automatically adjust forces using built-in sensors. Self-adjusting brackets with micro-robotics could gradually apply precise forces to reduce treatment time. AI-driven sensors will predict potential treatment delays and recommend adjustments in real-time.

4. AI + 5G for Remote Care: 5G networks will enable real-time AI analysis of patient scans from anywhere in the world. AI-powered remote monitoring tools will reduce clinic visits and allow orthodontists to track patient progress from their smartphones. Teleorthodontics will become more advanced, allowing orthodontists to provide instant consultations and treatment adjustments.

5. Virtual Assistants: AI chatbots will act as virtual assistants, answering patient queries, scheduling appointments, and providing treatment reminders. AI will analyse patient habits (e.g., aligner wear time) and provide real-time compliance feedback. Patients will get personalised oral hygiene recommendations based on AI-driven risk assessments.

6. Predictive Analytics: AI will use big data analysis to predict treatment success rates and suggest the most efficient treatment plans. Machine learning models will forecast how teeth will move over time, allowing orthodontists to prevent complications before they arise. AI could also help in early orthodontic intervention for children, predicting future orthodontic issues before they fully develop.

7. Ethical Advancements: AI-driven orthodontics will require new regulations and ethical guidelines to ensure patient data privacy and accuracy. More orthodontists will undergo AI training, integrating AI seamlessly into daily practice.

Conclusion

Artificial Intelligence is reshaping orthodontics by enhancing diagnostics, personalising treatments, and streamlining workflows. With ongoing advancements, AI is set to make orthodontic care more precise, efficient, and accessible, ultimately leading to better outcomes and higher patient satisfaction

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Talon Cusp: An uncommon occlusal anomaly – conservative management of two cases.

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Abstract

Talon cusp, a rare dental anomaly characterized by an extra cusp-like structure on anterior teeth, poses significant clinical challenges. This report presents two cases of talon cusp affecting maxillary central incisors, highlighting their clinical implications and successful conservative management.

The cases illustrate distinct complications, including premature contact, articulation difficulties, inadequate mouth closure, food impaction, and patient discomfort. A thorough literature review reveals variability in prevalence, etiology, and classification systems, underscoring the importance of radiographic evaluation and multidisciplinary approaches.

This report emphasizes the importance of early diagnosis and intervention to prevent complications and ensure optimal oral function and patient comfort. Conservative management strategies, including restorative and minor surgical interventions, are discussed, highlighting the potential for successful outcomes without extensive treatment.

Keywords: Talon Cusps, Problems, unilateral anomalous cups, conservative treatment

ORIGINAL ARTICLE

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Introduction

Talon Cusp, relatively rare developmental anomalies, present as accessory cusps resembling an eagle's talon, emanating from the cingulum area or cemento-enamel junction of anterior teeth, and so named for its semblance to an eagle's talon.[1,2]

These anomalies can occur in both deciduous and permanent dentition. The etiology of talon cusps is unknown, but it is often attributed to the evagination of inner enamel epithelium during the morpho-differentiation stage of tooth development. It appears to be a balance between both environmental and genetic factors (Heaton and Pickering, 2013).

Prevalence varies considerably among ethnic groups.[3] The variability in reported prevalence rates of talon cusps may be attributed to the lack of standardised classification criteria and inconsistent definitions.[4] To address this issue, Hattab et al. (1996) proposed a standardised talon cusp scoring system.[5] This system categorises talon cusps into three distinct types based on their morphology:

Type 1: A prominent projection extending from the cingulum to more than half the distance to the incisal edge.

Type 2: A well-defined projection extending less than half the distance to the incisal edge.

Type 3: A minor expression characterised by enlarged cingula and their variations.

This classification system aims to provide a clear and consistent framework for diagnosing and reporting talon cusps, particularly those occurring on the lingual and palatal surfaces.

Talon cusps are composed of normal enamel, dentine, and may contain pulp tissue.[6] They often attach to the incisal ridge, forming a T or Y shape, with no predilection for sex, although males are reportedly

more affected[6]. Once considered rare, radiographic examination has revealed a higher incidence.[7] Their presentation is mostly unilateral and on the incisal towards the palatal with fewer bilateral or labial presentation[5]. Clinically, talon cusps are significant due to potential complications, including aesthetic concerns, speech difficulties, breastfeeding problems, attrition, occlusal interferences, temporomandibular joint pain, accidental cusp fracture, displacement of affected teeth, interference with tongue space, irritation of tongue during speech and mastication, periodontal problems due to excessive occlusal forces, development of dental caries in developmental groove of the talon cusps.[4]
This article presents two case reports of talon cusp affecting permanent teeth, highlighting diverse associated complications and successful conservative treatment outcomes.

Case 1

A 10-year-old male patient presented to the clinic accompanied by his mother, who expressed concerns regarding his dental aesthetics, tongue irritation, and difficulty closing his mouth, leading to mouth breathing and teeth grinding. The patient's deciduous teeth erupted and exfoliated normally. However, upon eruption of his permanent teeth, his mother noticed him frequently grinding his teeth and complaining of tongue irritation. As the issue persisted, she observed that he struggled to close his mouth adequately, prompting her to seek dental consultation.

The patient is the eldest of four siblings (one male and three females), with no family history of similar dental anomalies. His mother reported a normal pregnancy, without any complications or medication use during the pre- and postnatal periods. There was no history of trauma or associated systemic health issues.

On examination, the patient was a healthy and energetic young boy, presented with fully erupted permanent dentition, excluding third molars. Soft tissue examination revealed minimal plaque accumulation on the palatal aspect of the maxillary central incisor and a slight diastema.

The patient exhibited a Class I molar relationship. Notably, both maxillary central incisors were slightly enlarged, with a prominent, horn-like projection palatally on the maxillary right central incisor (Figure 1). This talon cusp was large, well-defined, and hook-like, extending downward from the palatal surface of the crown, preventing adequate mouth closure.

The talon cusp exhibited a pointed, sharp tip with a slight curvature, causing tongue indentation. A moderate, non-carious dental groove was present at the junction of the talon cusp and the palatal surface of the tooth. Plaque accumulation and inflammation were observed around the marginal gingiva on the palatal surface of the maxillary right central incisor, eliciting slight bleeding on probing.

An occlusal radiograph confirmed the presence of a fully formed maxillary right central incisor, unaffected in its underlying structure (Figure 2). No additional dental anomalies or abnormalities were detected.

Treatment involved gentle reduction of the talon cusp using a high-speed turbine handpiece and diamond bur under copious water irrigation, without anesthesia, to assess sensitivity (Figure 3). Post-procedure, the patient was prescribed fluoride therapy and instructed to use fluoride toothpaste.

The patient was monitored closely through a series of follow-up appointments at weekly, bi-weekly, monthly, 3-month, and 6-month intervals, without any adverse reactions, such as color changes, pain, or periapical pathosis. Following an uneventful recovery, the patient was discharged.

A long-term follow-up examination four years later revealed that the tooth remained asymptomatic, indicating a successful treatment outcome.

Figure 2; talon cusps on tooth 11

Figure 1; Talon cusp on tooth 11

Figure 3; OPG showing talon cusp on tooth 11

Case 2

A 32-year-old female patient presented to the clinic with complaints of a projection and presence of an extra structure at the back of one of her teeth, along with intermittent pain originating from the affected tooth.

On examination, the patient was found to be a healthy young lady with a full complement of permanent dentition in a Class I molar relationship. The maxillary right lateral incisor appeared normal, with no discoloration. However, the palatal aspect revealed a horn-like projection attached to the cingulum, separated from the palatal surface by a small space that facilitated food entrapment and showed early signs of caries (Figure 4). Additionally, moderate cusp interference was observed, affecting normal occlusion.

The talon cusp was reduced through selective cuspal grinding utilising a flame-shaped diamond bur, accompanied by topical fluoride application. The patient was recalled monthly, and by the end of three visits, the cusp was virtually eliminated, although some sensitivity persisted (Figure 5). To ensure pulp protection, calcium hydroxide was applied, followed by a composite restoration.

The patient underwent an 8-month follow-up period, involving regular vitality testing and intra-oral radiographs. Throughout this time, the tooth remained asymptomatic with preserved vitality. Once stability was confirmed, the patient was discharged with instructions to return if any symptoms arose. To date, no further issues have been reported.

Figure 4: Talon cusp on tooth 12

Figure 5: periapical radiograph of Talon cusp on tooth 12

Discussion

Talon Cusp, also known as dens evaginatus, is a rare dental anomaly affecting anterior teeth. A systematic literature review and meta analysis reported a range of prevalence between 0.06 % and 40.8 %.[14] Its etiology remains unknown, but it is attributed to disruptions during the morpho-differentiation stages of tooth development. Although associated with various syndromes, most reported cases occur in isolation, primarily in the permanent dentition.[15] Notably, talon cusps are more prevalent in permanent teeth than deciduous ones.[7]

The talon cusp represents an extreme variation of normal tooth morphology, existing on a continuum that includes a normal cingulum, an enlarged cingulum (trace talon), a small accessory cusp (semi-talon), and a fully formed talon cusp.[5,8]

The two reported cases of talon cusp presented unilaterally in the maxillary incisors, consistent with previous reports.[15,16] However, the gender and age of the patients differed from previous studies. Our cases involved a male child and an adult female, whereas previous reports described female children[15-17] and adults.[5,6,17,18]

Notably, the location of the talon cusp varied between the two cases, affecting the right incisor in one and the left incisor in the other. This contrasts with a previous report where all cases occurred on the right side,[15] but aligns with another study that documented involvement of both right and left incisors.[16]

In agreement with some previous studies,[15] both cases involved central incisors exclusively. However, this differs from reports describing talon cusps on lateral incisors only[17,18] or both central and lateral incisors.[16]

Small talon cusps are typically asymptomatic and require no treatment. In contrast, larger talon cusps can pose significant challenges for both patients and clinicians, from diagnosis to treatment planning.[9]

The problems associated with talon cusps in the reported cases are consistent with previously documented issues.[15-18] Patients with talon cusps may experience compromised aesthetics, breastfeeding difficulties, tongue irritation during speech or mastication, occlusal interference, and periapical and periodontal issues.[2,5]

Dentists may face additional challenges, such as diagnostic difficulties, interference with orthodontic tooth movement, and increased risk of caries due to plaque and debris accumulation in the developmental groove.

The treatment of talon cusps requires meticulous planning, contingent upon the presence or absence of pulp tissue within the cusp. However, radiographic assessment is often hindered by the superimposition of the horn over the affected crown, and histologic examination may not reliably detect pulp tissue in the anomalous cusp.[10,11]

In the reported cases, treatment was facilitated by the cusp's size and composition. The smaller cusp was successfully managed with grinding, without complications. The second tooth initially exhibited sensitivity, which resolved subsequently. This outcome aligns with previous reports where selective grinding and fluoride varnish application were effective.[15,18]

Interestingly, the adult case presented similarly to paediatric cases, with comparable treatment outcomes. This contrasts with previous reports where adult patients required more extensive treatment, including grinding and root canal therapy.[17,18]

Early diagnosis and timely treatment of talon cusps are crucial in preventing associated complications. Reports have highlighted the risks of anterior teeth subjected to shearing forces, leading to displacement of occluding teeth and potential fracture of the anomalous cusp.[9]

Prompt intervention is vital in maintaining the pulp-dentin complex's integrity, essential for preserving functional dentition. Selective grinding, fluoride varnish application, and sealant use can be enhanced by the natural formation of reparative dentine over time. Research indicates that reparative dentine formation occurs more rapidly in primary teeth than permanent teeth, and its thickness increases with time, proportional to the remaining dentine thickness.

Studies[12,13] provide valuable guidance on timed periods of selective grinding, emphasising the importance of close monitoring for color changes, vitality changes, and radiographic changes.

Early intervention and careful monitoring enable clinicians to mitigate potential complications and ensure optimal outcomes for patients with talon cusps.

Conclusion

Talon cusp is a rare developmental anomaly affecting anterior teeth, leading to varied clinical issues depending on its presentation. Prompt diagnosis and intervention are crucial in preventing complications. The two cases presented demonstrate the effectiveness of conservative treatment approaches, which were successfully employed to manage the anomaly. Therefore, conservative management is recommended for talon cusp cases, emphasising the importance of early detection and timely intervention.

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Conflict of Interest - None to declare

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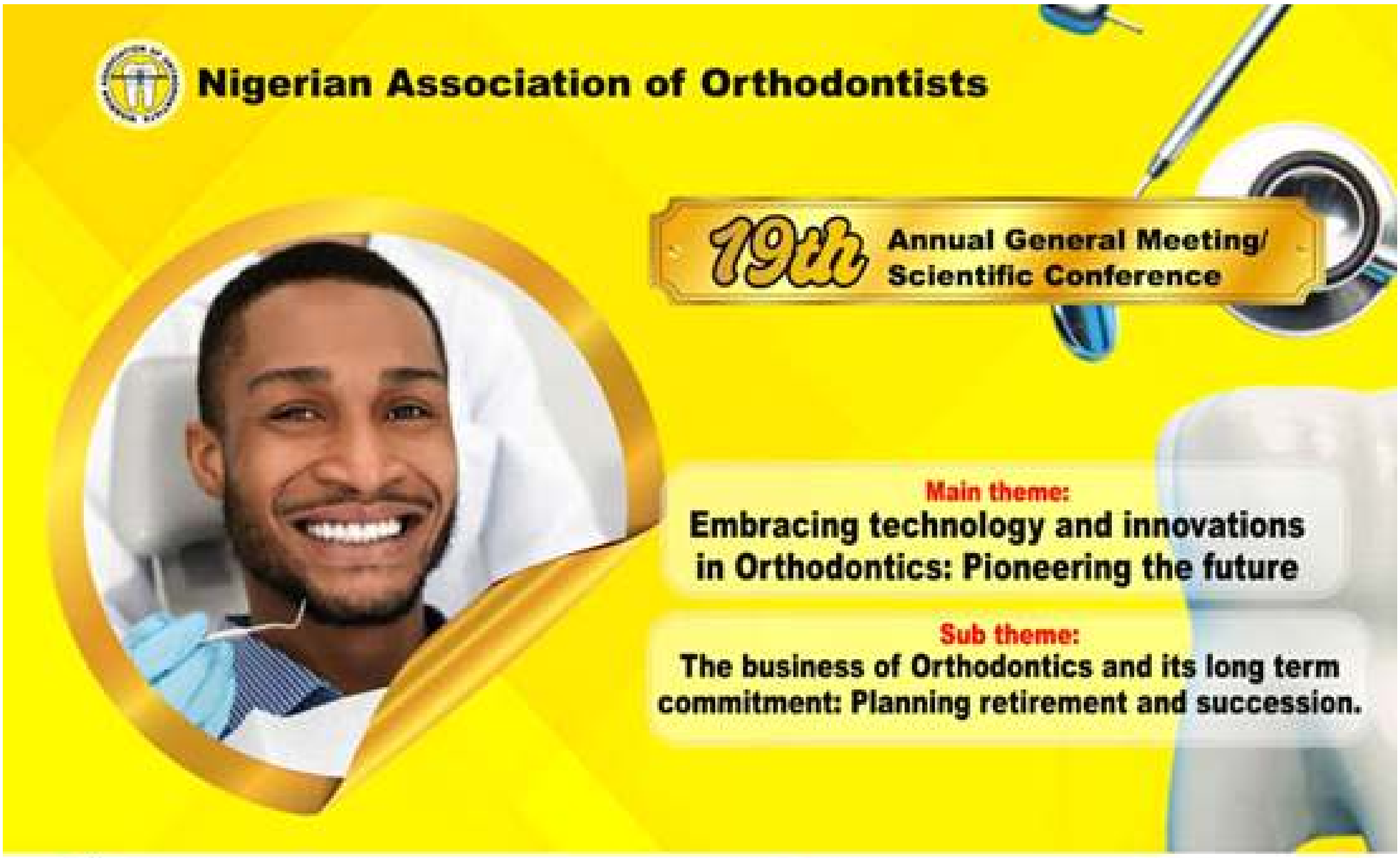

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Each table should be typed in double-space on a separate sheet of paper. Tables not submitted as photographs must be numbered consecutively (Arabic numerals) in the order of their first citation in the text, with a brief but self explanatory title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