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Cephalometric characteristics of South African Black patients presenting at an academic oral health centre

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R Kobedi,[1] S Rajbaran-Singh,[2] HF Swanepoel,[3] AC Oettlé[4]

ABSTRACT

Introduction

Cephalometric analysis is central to the diagnosis, treatment planning and successful management of dental malocclusion and skeletal discrepancies. While interpopulation variations in skeletal morphology have been documented, limited research is available in the South African context. This study contributes to developing literature describing cephalometrics in a South African Black population.

Aims and objectives

The study aimed to assess the cephalometrics of a sample of South African Black adults according to Wits appraisal categories and to examine variations according to sex and age.

Design

This was a cross-sectional quantitative study examining archived lateral cephalograms.

Methods

The study analysed 114 lateral cephalograms (63 females, 51 males). ImageJ software was used for cephalometric measurements. Statistical analysis was performed using PAST statistical programme.

Results

Across Wits appraisal categories significant differences were revealed in the ANB and SNB angles. The extent of mandibular protrusion was greater in males, while the extent of maxillary protrusion was greater in females. In females, where the gnathic index was found to significantly increase with increasing age, the gonial angle significantly decreased

Conclusion

The variations noted in cephalometric analysis of South African Black patients warrants the investigation of contextual consideration for orthodontic assessments and treatment.

Authors' Information

1. Ms Ruth Kobedi. BSc MedSci, BSc (MedSci) (Hons), MSc (Med), Department of Anatomy and Histology, School of Medicine, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa. Telephone: (012) 521 4430 Email: deekobedi@gmail.com. ORCID: 0000-0002-0891-0899
2. Dr Sandeepa Rajbaran-Singh. MSc.Odont, Dip.Odont, BChD, Department of Maxillofacial and Oral Radiology, School of Oral Health Sciences, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa. Telephone: (012) 521 4902 Email: sandeepa.singh@smu.ac.za ORCID: 0000-0002-7313-1365
3. Dr Helene Franci Swanepoel Manuscript development. BSc MedSci, BSc (MedSci) (Hons), MSc (Anat), PhD (Anat), Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology. Email: swanepoelHF@tut.ac.za. ORCID: 0000-0001-6297-1775
4. Prof Anna Catherina Oettlé. MBBCh, MSc (Anat) (cum laude), PhD (Anat), DTE. Department of Anatomy and Histology, School of Medicine, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa. Telephone: (012) 521 3337 Email: profoettle@gmail.com. ORCID: https://orcid.org/0000-0002-5665-6581

Corresponding Author

Name: Ms Ruth Kobed
Telephone: (012) 521 4430
Email: deekobedi@gmail.com

Authors Contributions

1. Ms Ruth Kobedi
   Role: principal researcher, manuscript development and write-up: 60%
2. Dr Sandeepa Rajbaran-Singh
   Role: conception and manuscript editing: 10%
3. Dr Helene Franci Swanepoel Manuscript development
   Role: manuscript editing 10%
4. Prof Anna Catherina Oettlé
   Role: conception, data analysis, manuscript development and editing 20%

INTRODUCTION

Cephalometric analysis is the primary method employed by orthodontists in the management of facial skeletal morphology and dentoskeletal relationships, aiding in the assessment of malocclusion and other associated skeletal deformities. The occlusion status of patients is assigned to one of three levels of Angle's classification based on the sagittal relationship of maxillary and mandibular first molars resulting in either an aligned maxilla and mandible (Class I malocclussion), a retruded mandible (Class II malocclusion) or a protruded mandible (Class III malocclusion).[1] Prognathism, on the other hand, does not necessarily indicate misalignment or jaw disharmony, and the extent of prognathism may normally vary between individuals and population groups.[2-3]

People of African ancestry have been reported to present with higher degrees of maxillary and mandibular prognathism compared to people of European ancestry.[3-7] Populations of African ancestry with aligned occlusion but with maxillary and mandibular protrusion showed a lower cranial base angle (SNAr) and shorter cranial base (SN distance), when compared to groups of European decent.[7] These features confer a posterior position of the nasion point (N), influencing all measurements related to the sella point (S) or the SN line.[7]

The use of angular measurements that incorporate the relative positions of the jaws to craniofacial landmarks—such as the ANB angle (formed between points A (subspinale), N (nasion), and B (supramentale)) or the SNA and SNB angles (which include the sella)—may introduce interpopulation disparities due to variations in the anatomical positioning of these structures.[8] Additionally, variability appears greater in angular than linear data.[9] The "Wits appraisal" of jaw disharmony is a

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linear measure of the extent to which the jaws are related to each other anteroposteriorly. During cephalometric tracing, the Wits appraisal is measured from points A and B onto the occlusal plane.[8] The occlusal plane is represented by a line drawn through the region of maximum cuspal interdigitation. The points of contact on the occlusal plane from points A and B are termed AO and BO, respectively. By using the Wits appraisal, the possible interpopulation variations in the relative positions of the sella and nasion because of a shortened cranial base can be excluded.

Utilising the Wits appraisal, a positive reading would convey that point BO would be positioned posterior to point AO in skeletal Class II jaw dysplasias. In Class III skeletal jaw disharmonies, a negative reading would convey that point BO is positioned anterior to point AO. Previous reports on small samples[9-10] have indicated that in class I, AO and BO coincided in females while point BO was located 1 mm ahead of point AO in males. Zaffiri et al. (2024) however, found no significant difference between sexes in the Wits appraisal.[11] The Wits appraisal was therefore the primary reference used to classify and describe malocclusion in our study, as it has been reported to provide the highest coefficient of variability for evaluation of jaw relationships.[12-13] Unfortunately, there is paucity in the literature regarding cephalometrics associated with malocclusion (such as SNA angle, SNB angle and ANB angle among others) in Black individuals across the world, and no studies could be found regarding these angles in a South African context.

Table I: Cephalometic landmarks used to quantify prognathism and malocclusion.

Landmark	Abbreviation	Definition
A point	A	The point of the deepest concavity anteriorly on the maxilliary alveolus.[8]
B point	B	The point of the deepest concabity anteriorly on the mandibular symphysis.[8]
Sella	S	The midpoint of the stella turcica.[8]
Nasion	N	The most anterior point on the fronto-nasal suture.[8]
Anterior nasal spine	ANS	Tip of the median sharp bony process of the palatine bone in the hard palate.[8]
Posterior nasal spine	PNS	Tip of the posterior spine of the palatine bone of the hard palate.[8]
Gonion	Go	The point is located at the mandibular angle, where a perpendicular line is dropped from the intersection of two tangents - one along the posterior margin of the mandibular ramus and the other along the inferior margin of the mandibular body. (Figure. 1) [51]
Menton	Me	The most inferior point on the mandibular symphysis (Linjawi et al., 2021).
Prosthion	Pr	Most anterior point in the midline on the alveolar process on the maxilla (Martinez et al., 2017).
Basion	Ba	The lowest point on the anterior rim of the magnum foramen (Martinez et al., 2017).

Additionally, very few studies investigate age-related changes in the cephalometrics of adults. The rising number of adults seeking orthodontic treatment and orthognathic surgery[14] warrants exploration of age-related changes in cephalometrics. Although changes in adult cephalometrics may be subtle, identifying these adult changes can help distinguish between post-orthodontic relapse and normal developmental or maturation processes.[15-16] Understanding adult craniofacial changes therefore, is crucial for effective treatment planning in surgical orthodontic cases.[17] Majority of dental standards have been obtained from adolescent samples.[18-21] This study aimed to determine the cephalometric characteristics according to the Wits appraisal category in South African Black adults referred to an academic oral health centre. Lateral cephalograms were evaluated to assess how cephalometric measurements vary according to sex and age.

MATERIALS AND METHODS

A total of 114 (63 females and 51 males) lateral cephalograms were retrospectively collected from the SMU Oral Health Centre for patients aged between 18 years and 58 years, who were referred for malocclusion and skeletal analysis prior to orthodontic treatment. The maximum age of 58 years was based on data availability and not for any other cut off reasons. Only cephalograms without the evidence of bone trauma, orthodontic braces, tooth loss or tooth restorations were included for analyses. The sample was selected by means of a convenience sampling strategy.

All data acquisition was performed using ImageJ software programmeme.[22] The relevant cephalometric landmarks, planes and abbreviations used for analysis are described in Table I, Table II and Table III respectively. The measurements and the normative values are also described in Table III. Figure 1 illustrates the landmarks taken and Figure 2 illustrates

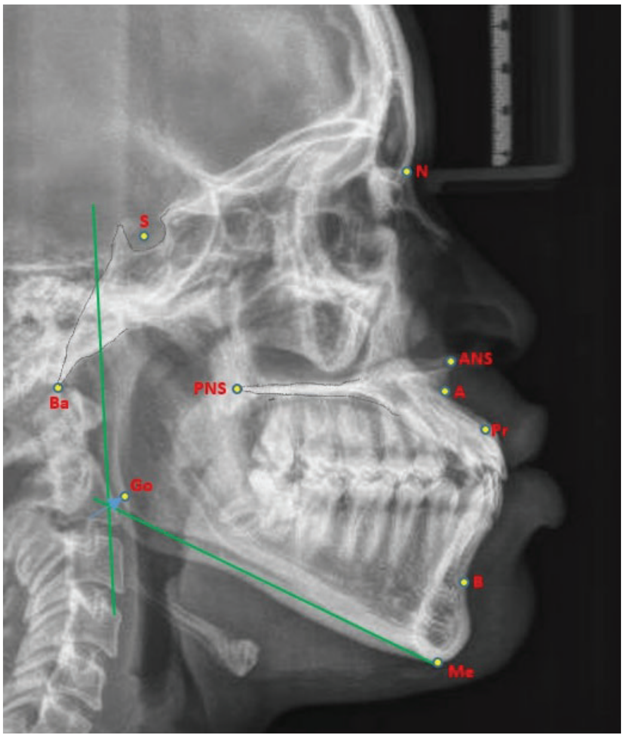

Figure 1: Cephalometric landmarks used to quantify malocclusion. The green lines indicate tangent lines to the posterior margin of the mandibular vertical ramus and inferior margin of the mandibular body, where a perpendicular point was dropped at their intersection to the mandibular angle (to indicate the gonion landmark).[51]

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Table 2: Cephalometic planes

Plane/ Relationship	Description
Stella-Nasion line	The plane created by a line through the nasion and sella.[53]
Mandibular plane	Tangent line drawn at the lower border of the mandible.[51]
Mandibular ramus plane	Tangent line drawn along the posterior margin of the mandibular ramus.[51]
Maxillary (palatal) plane	The plane demonstrated by a line through the anterior and posterior nasal spines.[8]
Nasion A-point plane	The plane demonstrated by a line drawn from nasion to A-point.[53]
Nasion B-point plane	The plane demonstrated by a line drawn from nasion to B-point.[53]
Occlusal plane (O)	An imaginary surface that touches the incisal edges of the incisors and the tips of the occluding surfaces of the posterior teeth.[8]
AO point	Point of contact on the occlusal plane as projected from A point at 90 degrees.[8]
BO point	Point of contact on the occlusal plane as projected from B point at 90 degrees.[8]

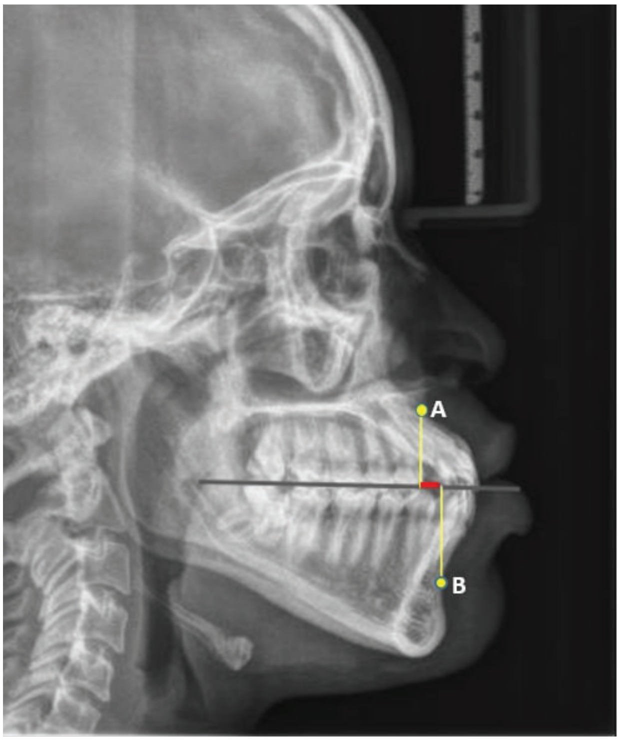

Figure 2: Grey horizontal line = occlusal plane, yellow line from A point to occlusal plane at 90 degrees; yellow line from B point to occlusal plane at 90 degrees; Wits appraisal = red horizontal line

Table 3: Cephalometic measurements derived from the planes

Parameter	Abbreviation	Description	Norms	
			Internationally established	Previously established in South Africa
Sella-Nasion-A point angle	SNA	Main parameter for relative anteroposterior position of the maxilla to the cranial base.[8,54]	82°	
Sella-Nasion-B point angle	SNB	Main parameter for relative anteroposterior position of the mandible to the cranial base.[8,54]	80°	
A point-Nasion-B point angle	ANB	Relative anteroposterior position of the maxilla to the mandible and can be used to determine skeletal class.[33,55]	2°	
Inter-Incisal angle	IIA	The angle between the long axis of the maxillary incisors and the long axis of the mandibular incisors.[8,45]	131°	
Maxillary Incisal Inclination	MxII	The angle between the maxillary plane and the long axis of the maxillary incisors assessing relative maxillary protrusion.[8]	112.5° (females) and 111.0° (males)	
Mandibular Incisal Inclination	MnII	The angle between the mandibular plane and the long axis of the mandibular incisors assessing relative mandibular protrusion.[8]	95.6°	
Gonial angle	GoA	The angle formed at the point of intersection of a line tangent to the lower border of the mandible and another line tangent to the border of the ascending ramus and the condyle (Figure 3).[29,39]		121° and 122°
Wits appraisal		Distance between AO and BO where the reading is positive if BO is behind AO and negative if BO is anterior to AO (Figure 2).[8,10]		0 mm (females) and 1 mm (males)
Gnathic index	GI	Main parameter for relative maxillary protrusion:[35] Ratio of basion-prosthion length to basion-nasion length , calculated with the formula:	98 – 103	

Internationally established norms were obtained from European populations for SNA[28], SNB[28], ANB[28], IIA[28], MxII[44], MnII[44] while the population group for gnathic index[35] was not specified. The previously established South African norms reported were from black populations for gonial angle[36,37], while the population groups for Wits appraisal[10] were not specified.

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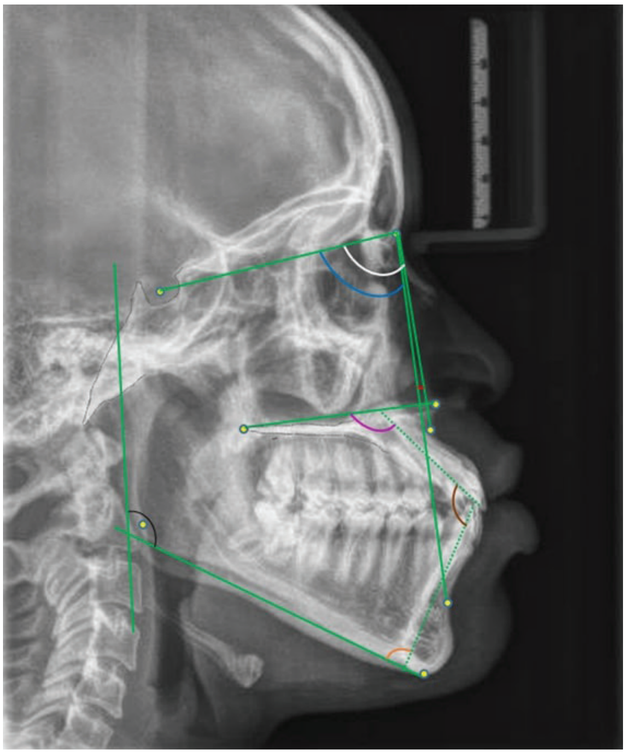

Figure 3: Cephalometric planes and angles measured. The green solid lines indicate planes defined in Table II. The green dotted lines indicate the long axis of maxillary and mandibular incisors. The angle identifiers are as follows as defined in Table III: SNA – white; SNB – blue; ANB -red; MxII – purple; IIA – brown; MnII – orange; GoA - black

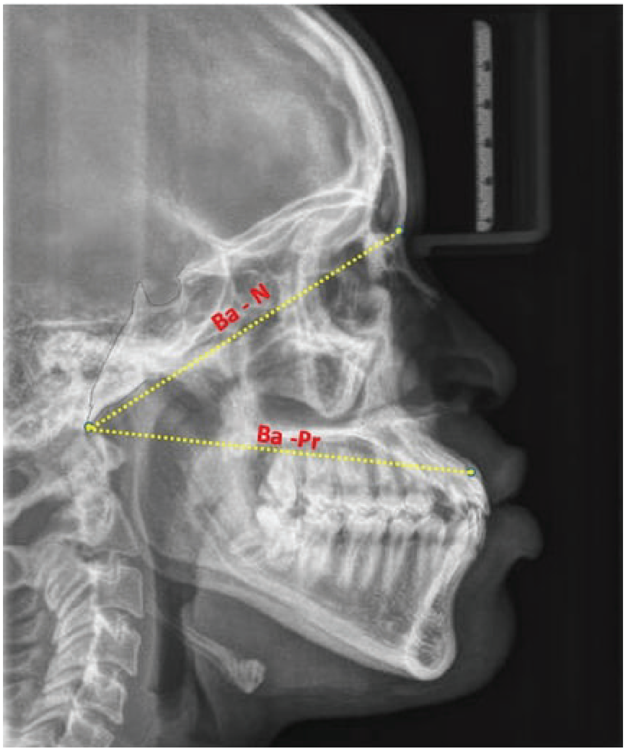

Figure 4: Landmarks for the gnathic index

the Wits appraisal. The angles are further illustrated in Figure 3 and gnathic index in Figure 4. The scale of each cephalogram was calibrated before landmark-based data was collected to determine angles and linear distances. The sample was classified into a negative, positive and zero Wits appraisal categories regardless of sex. The possible sexual dimorphism in the occurrence of zero, negative and positive Wits appraisal was studied.

Table 4: Intra-0bserver error

Measurement	ICC	99% Confidence Interval	
		Lower bound	Upper bound
SNA angle	0.94	0.79	0.98
SNB angle	0.91	0.77	0.95
ANB angle	0.93	0.76	0.98
IIA	0.97	0.86	0.99
MxII	0.91	0.78	0.97
MnII	0.76	0.69	0.83
GoA	0.92	0.81	0.93
Gnathic index	0.98	0.88	0.99
Wits appraisal	0.96	0.85	0.97

Statistical analysis was performed using Paleontological Statistics (PAST) software.[23] First, descriptive analysis was performed on all data. A Shapiro-Wilk test was then used to assess normality.

Based on the results, either parametric (one-way ANOVA with Tukey's pairwise comparisons) or non-parametric (Kruskal-Wallis with Mann Whitney's pairwise comparisons) tests were applied[24] to compare cephalometric parameters between groups (sex-Wits appraisal categories). A p-value of ≤ 0.05 was considered statistically significant. Correlation tests (where r = coefficient of correlation, r^2 = coefficient of determination and p = probability) were performed to assess the relationship between age and various cephalometrics. Pearson's correlation coefficient (r) was used for normally distributed variables, while Spearman's correlation coefficient was applied for non-normally distributed variables.[25] A value of r = +1 indicated a perfect positive correlation, r = -1 indicated a perfect negative correlation, and r = 0 indicated no linear association.[26]

Intra-observer reliability for measurement accuracy was conducted by the principal researcher. Ten percent of the sample (N = 11) was randomly selected from the entire sample and analysed twice by the principal researcher to assess the intra-observer reliability. Measurement repeatability was determined using an intraclass correlation coefficient (ICC: 2, k) classification, where k is 2 since there were two measurements for every variable).[27] This approach determined coefficiency based on analyses performed twice by the researcher.

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Table 5: Univariate analysis of cephalometric dimensions for the entire sample, females and males according to occlusal relationships (Wits appraisal categories).

Groups per Wits appraisal category	SNA (°)	SNB (°)	ANB (°)	IIA (°)	MxII (°)	MnII(°)	GoA (°)	Gnathic Index	Wits appraisal (mm)
Entire sample	**83.58**	**82.65[a]**	**1.38[c]**	**110.57**	**125.42**	**90.02**	**124.42**	**102.30**	**-5.09[h]**
(-)	*5.89*	*4.85*	*5.35*	*7.78*	*6.01*	*7.17*	*6.83*	4.97	*4.45*
N = 53	(68.04-100.19)	(73.15-96.52)	(-18.32-10.44)	(86.89-125.84)	(111.98-136.33)	(76.25-108.01)	(113.53-142.52)	(87.70-116.62)	(-23,34-(-0,52))
Females	**83.71**	**81.28**	**2.86[df]**	**110.42**	**124.58**	**89.7[g]**	**125.74**	**102.55**	**-4.47[i]**
(-)	*5.24*	*4.67*	*4.04*	*7.88*	*6.40*	*7.80*	*6.78*	*4.40*	*2.97*
N = 26	(76.33-99.72)	(73.15-93.04)	(-10.32-9.98)	(96.78-125.84)	(111.98-136.03)	(76.25-107.93)	(114.28-142.52)	(93.85-111.54)	(-13,93 -(-0,77))
Males	**83.46**	**83.98[b]**	**-0.05[de]**	**110.71**	**126.22**	**90.32**	**123.15**	**102.06**	**-5.70[j]**
(-)	*6.57*	*4.72*	*6.11*	*7.83*	*5.61*	*6.65*	*6.75*	*5.54*	*5.52*
N = 27	(68.04-100.19)	(73.39-96.52)	(-18.32-10.44)	(86.89-124.99)	(115.07-136.33)	(77.02-108.01)	(113.53-133.84)	(87.70-116.62)	(-23,34 -(-0,52))
Entire sample	**87.09**	**82.81**	**4.35**	**112.88**	**123.46**	**90.45**	**122.24**	**105.21**	
(0)	*3.96*	*4.05*	*1.69*	*8.34*	*6.22*	*8.16*	*6.19*	*5.62*	-
N = 7	(83.23-94.47)	(78.51-90.84)	(1.66-6.59)	(98.69-121.41)	(116.03-134.45)	(74.19-98.31)	(116.64-133.08)	(98.81-113.44)	
Entire sample	**85.33**	**79.94[a]**	**5.28[c]**	**106.21**	**124.75**	**92.80**	**123.90**	**103.70**	**2.94[h]**
(+)	*4.76*	*4.30*	*3.20*	*8.05*	*6.89*	*6.41*	*5.71*	*4.97*	*2.00*
N = 54	(77.83-99.70)	(72.54-92.54)	(-3.20-13.45)	(90.29-123.09)	(109.73-140.58)	(80.71-107.60)	(106.03-137.11)	(89.83-116.27)	(0.31-7.93)
Females	**85.79**	**79.78**	**5.97[f]**	**104.93**	**125.70**	**93.57[g]**	**125.23**	**103.90**	**3.25[i]**
(+)	*5.15*	*4.22*	*2.89*	*7.77*	*7.28*	*5.94*	*5.20*	*4.79*	*1.76*
N = 31	(77.83-99.70)	(72.54-88.60)	(1.09-13.45)	(90.29-123.09)	(109.73-140.52)	(80.71-104.27)	(115.64-137.11)	(94,70-114,41)	(0.60-7.93)
Males	**84.73**	**80.16[b]**	**4.37[e]**	**107.94**	**123.47**	**91.77**	**122.11**	**103.43**	**2.51[j]**
(+)	*4.21*	*4.48*	*3.43*	*8.28*	*6.27*	*7.00*	*5.98*	*5.31*	*2.26*
N = 23	(80.23-96.76)	(72.77-92.54)	(-3.2-9.32)	(92.34-121.26)	(114.93-140.58)	(81.84-107.60)	(106.03-132.56)	(89.83-116.27)	(0,31-6,93)

Number of individuals = N; mean values are indicated in bold; standard deviation is indicated in italics; range is shown within the round (brackets); repeating alphabet letters in the superscript indicate statistically significant differences (p value < 0.05) between categories/sexes per parameter. Wits appraisal categories are indicated by (+) for positive reading; (-) for negative reading; (0) for readings with zero.

Statistical comparisons involving males in the Wits category of zero (0) could not be made as N = 1 for that category, and thus comparisons with female in the same category (N=6) were not made

RESULTS

The intraclass correlation coefficient (ICC) tests for intra-observer error (Table IV) indicated excellent measurement agreement, with 95% confidence intervals of good to excellent, except the mandibular incisal inclination (MnII), which showed good measurement agreement (ICC – 0.76) and a 95% confidence interval of moderate to good.

In the entire sample, parametric data included the Sella-Nasion-B point angle (SNB), inter-incisal angle (IIA), maxillary incisal inclination (MxII) angle, MnII angle, gonial angle and gnathic index on which one-way Anova with Tukey's pairwise comparisons tests were applied. Non-parametric data included the Sella-Nasion-A point angle (SNA), A point-Nasion-B point angle (ANB), and Wits appraisal, where the Kruskal-Wallis with Mann-Whitney's pairwise comparisons were applied. In the sex group comparisons, parametric data included the SNA angle, SNB angle, IIA, MxII angle and gonial angle, whereas the ANB angle, MnII angle, gnathic index and Wits appraisal were non-parametric.

The summary statistics for the cephalometrics of each group (entire sample, females and males) per Wits appraisal reading category (negative (-), positive (+) and zero (0)) are shown in Table V. There were no statistically significant variations noted in the parameters between males and females of the same Wits appraisal reading (female negative vs male negative; female positive vs male positive), except for the ANB angle which was significantly larger in females than males of the negative Wits appraisal category (Table V). Sex comparisons could not be made in the zero Wits appraisal category as there was only one male in that category.

There were no statistically significant differences for SNA, IIA, MxII, GoA or gnathic index between Wits appraisal categories in the entire sample, within sex groups or between

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sex groups. The SNB angle was significantly larger in the negative compared to the positive Wits appraisal categories for the entire sample and when comparing negative males to positive males. ANB was significantly smaller when comparing the negative Wits appraisal category to positive Wits appraisal category in the entire sample and when comparing negative females and males to positive females and males respectively. For MnII, negative category females were statistically smaller than positive category females. The gnathic index was larger in positive Wits appraisal groups when compared to the negative groups but not statistically significantly so. The mean Wits appraisal values were far smaller (< 0 mm) in the negative groups, while they were greater than 0 mm in the positive groups. Sex variations in the mean Wits appraisal showed smaller values in males when compared to females.

Females displayed larger SNA angles and smaller SNB angles in all categories while males displayed larger SNB angles and smaller SNA angles in the negative Wits appraisal group. Sex variations showed that the SNA was larger in females compared to males in all groups and the SNB was larger in males than females in all groups. ANB in males of the negative Wits appraisal category was significantly smaller than in females of the negative Wits appraisal category.

In the entire sample, significant weak positive correlations were observed for SNA (r = 0.18; r2 = 0.03; p = 0.05), gnathic index (r = 0.21; r2 = 0.04; p = 0.03) and Wits appraisal (r = 0.18; r2 = 0.04; p = 0.04), while significant weak negative correlations with age were noted for the gonial angle (r = -0.19; r2 = 0.04; p = 0.04). Age correlations in the entire sample did not follow a homogenous pattern and therefore correlations were evaluated separately for each sex. Age correlations were weak in both sexes, but weaker in males than females. In females, the gonial angle decreased significantly with age (r = - 0.33; p = 0.01), while the gnathic index increased significantly with age (r = 0.36; p = 0.00). These same parameters (gonial angle and gnathic index) in males were weaker and negative when compared to females, and they were not significant.

Furthermore, age correlations were performed for Wits appraisal categories and all correlations were weak and insignificant, except the gonial angle, which had a significant weak negative correlation (r = - 0.26; r2 = 0.07; p = 0.04) in the Wits category of both zero and positive combined (due to the small sample size in the category of zero, cephalometrics of that group were combined with those of the positive group when correlating age).

DISCUSSION

The results of this study present cephalometric data specific to Black South African orthodontic patients, emphasising characteristic features associated with malocclusion.

The negative Wits appraisal category in Table V represented class III with mean Wits of -5.09 mm and mean ANB of 1.38°. As expected for skeletal class III, the mean SNB angle of 82.65° and the mean gonial angle of 124.42°, were greater than the norms which is consistent with mandibular protrusion.[28-34] The gnathic index of 102.30 coheres with the position of a maxilla in normal occlusion35, while the SNA of 83.58° would be associated with a protrusive maxilla (SNA > 82°).[28,34]

The positive category, associated with skeletal class II (ANB > 4°; Wits: 2.94 mm) showed a relative protrusion of the maxilla, which was further corroborated by a larger SNA and gnathic index than those in normal occlusion.[28,34-35] The mean SNB of 79.94° in the positive group seemed to indicate a normal mandibular position and was significantly smaller than the SNB in the negative Wits appraisal category. The mean gonial angle of 123.90° in the positive group, although smaller than the one in the negative group, was still greater than the norms (> both 121° and 122° as established by Oettlé et al., (2009)36 and Pillay at al., (2017)[37] respectively). Reasons for this difference could include the different modalities used, where dried skeletal collections were used in a study by Oettlé and colleagues (2009)[36] and panaromic radiographs in a study by Pillay and colleagues (2017), [37] whereas lateral cephalograms were used in this study. While it has been reported that cranial dimensions from radiographs were generally larger than those on cadaveric data,[38] there should not be any differences between the gonial angles measured on panaromic radiographs versus lateral cephalograms.[39] Other factors that may account for differences in gonial angle include variations in age ranges, dentition status, and the representation of the sexes across the different studies.

Our findings of a protrusive maxilla in class II malocclusions are not surprising. In a study by Rosenblum (1995),40 maxillary protrusion was found in 56% of class II malocclusion samples, while it was as a result of mandibular retrusion in 27% of the sample, and the other 17% had neither maxillary protrusion nor mandibular retrusion. In an adult Indian sample,[41] Sinha and colleagues (2018) noted that 27% of class II malocclusion samples presented with maxillary protrusion and 68% comprised mandibular retrusion (retrognathism), and the smallest portion of the sample (5%) had both a protrusive maxilla with a retrusive mandible.

Only 7 individuals in the entire sample had Wits appraisal readings of zero, which is categorised as class I malocclusion. Cephalometrics in this category in our study were associated with both a protrusive maxilla and protrusive mandible. For maxillary protrusion, these were marked by the SNA of 87.09° (which was > 82°) and gnathic index of 105.21 (which was > 103). For protrusive mandible, an SNB of 82.81° (which was > 80°) and gonial angle of 123.90° (which was > 122°).

An older study by Bacon et al., (1983)[4] reported similar findings for black individuals with class 1 malocclusion, where their SNA angle of 88° and SNB angle of 84° indicated a combination of protrusive maxilla and mandible. This finding of maxillary and mandibular protrusion[4] was concluded to be normal in black individuals especially when compared to white individuals, who in their study did not demonstrate distinguished protrusion of the jaws. These findings were corroborated by the study of Dandajena and Nanda (2003),[42] who studied an adult black Zimbabwean sample, and found that class I malocclusion individuals presented with both maxillary and mandibular prognathism.

Sex variations in these Wits appraisal categories showed that there were no statistically significant variations (negative versus negative; positive versus positive) except for the ANB angle. The ANB angle (a marker for relative maxillary protrusion) was larger in females than males in both the positive and negative Wits appraisal categories and significant (p = 0.04) in the female negative category (2.86°) than the male negative category (-0.05°). A greater ANB angle in females would also imply a more pronounced relative maxillary protrusion in class II malocclusion compared to

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males. Sex variations displaying a greater ANB in females was also noted in American White populations (orthodontic setting, pre-treatment).43 The greater ANB in females emphasise the notion of a relatively more forward projecting maxilla in females as opposed to males.

The larger SNB angle, indicative of mandibular protrusion, was greater in males than in females across both Wits appraisal categories. Independent of the Wits appraisal category, the distance between AO and BO was more positive in females than in males in both categories: -4.47 mm vs. -5.70 mm and 3.25 mm vs. 2.51 mm. Although not statistically significant, these trends further support the observation of a more protrusive mandible in males than in females across categories and would contribute to a more pronounced class III malocclusion in males. A more protrusive maxilla in females compared to males would contribute to a more pronounced class II malocclusion in females.

In class II malocclusion the SNA angle is expected to be larger than the SNB angle.32,34,40-41 This pattern was also noted in our study across all positive categories. The pattern of the SNB angle being larger than the SNA angle in class III malocclusion cases has been frequently reported in the literature.29,31-33 The mean values of a larger SNB angle than SNA angle in class III categories was only noted in males (N = 27). For females in the class III malocclusion category (N = 26), with mandibular protrusion (SNB: 81.28°), the SNA angle could exceed the SNB angle if the nasion is situated more posteriorly (see Figure 3). A posteriorly positioned nasion is associated with a shorter anterior cranial base as previously described in individuals of African descent.[7]

In the literature,[32] the mandibular incisal inclination (MnII) angle was smaller in class III malocclusions compared to classes I and II. Our study followed a similar pattern (Table V). Beyond the markers of malocclusion discussed in the Wits appraisal groups, our groups consistently showed features of both maxillary and mandibular prognathism. The MxII angles (Table V) were all larger than the established norms[44] of 112.5° for females and 111.0° for males and are indicative of maxillary prognathism in our samples.[29]

The smaller MnII angle in our study compared to the normal pre-established values44 (< 95.6°) indicates the presence of mandibular prognathism especially in the negative categories where they are even smaller than those in the positive categories. A smaller MnII angle in mandibular prognathism (84°) was also noted by Chang et al., (2006)[29] when compared to the normal established values in their study (98°).

The normal interincisal angle (IIA) according to Steiner (1959)[28] is 131°. The IIA noted in our study across all groups were far smaller than Steiner's normative value. According to Wei (1969), a smaller IIA indicates an anterior projection of either the maxilla, mandible or both.[45]

When sexes were evaluated separately, all cephalometric parameters showed weak correlations with age. The gonial angle in females indicated a significantly smaller angle with aging as also previously reported (Oettlé et al., 2016).[46] Although the correlations were weak, they were however stronger in females than those of males. The gnathic index had a significant positive correlation in females, which might be associated with enhanced maxillary prognathism with aging. The gonial angle and gnathic index decreased with age in males (although not statistically significant). Although a decrease in gonial angle has been reported in the literature,[47] varying reports on the correlations with aging have been found in the literature.[48] Unfortunately, the presence or absence of teeth is not always documented, which appears to be the primary factor preventing a decrease in the gonial angle with continued mastication as one ages.[46] There was no literature found which reported gnathic index correlations with age. The parameters which showed statistically significant increases with aging (SNA and gnathic index) are associated with more prognathic jaws especially of the maxilla while that which showed a statistically significant decrease with aging (gonial angle) is associated with a more retracted mandible.

The results of this study reflect a sample referred to a single academic institution and does not necessarily reflect facial skeletal dimensions of all Black South Africans. Further studies including other groups could enhance the applicability of the findings and norms that represent the general population could then be developed. As no single parameter should be relied on entirely for diagnostic purposes and for assessing orthodontic progress,[9,49] the determination of other cephalometrics associated with each Wits appraisal category are proposed towards deriving specific cephalometric norms for Black South Africans.

Findings from this study will be applicable in orthodontics for case related diagnosis, treatment design and growth estimation within the adult categories[28] and therefore improving management of malocclusion in the Black South African population group.[50]

CONCLUSION

In this study cephalometrics of positive and negative Wits appraisal categories, respectively corresponding to Class II and Class III malocclusion in South African Black adult lateral cephalograms are presented. Our groups consistently showed features of both maxillary and mandibular prognathism across malocclusion categories. In the comparison between sexes, males presented with a more protrusive mandible (a more pronounced class III malocclusion), while females presented with a more protrusive maxilla (a more pronounced class II malocclusion) which progressed with age. Future studies could expand the limited Class I malocclusion sample and establish reference values for normal occlusion individuals.

ETHICAL CONSIDERATIONS

Ethical approval from the Research Ethics Committee at Sefako Makgatho Health Sciences University (SMUREC/M/274/2023:PG) has been obtained for this study.

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CONFLICTS OF INTEREST:

None.

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CPD questionnaire on page 510

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