Hard tissue characteristics of patients with bimaxillary protrusion

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ABSTRACT

Introduction

Bimaxillary protrusion (BP) is a common developmental condition amongst the South African Black population characterized by proclined incisors with resultant procumbency of the lips.

Aims

The aim of this study was to perform a cephalometric radiographic analysis of the pre-treatment dental and skeletal structures in a sample of Black South Africans in order to identify the characteristic features of BP in this race group and compare them to norms.

Materials and methods

Records of 67 South African Black patients divided into 28 males and 39 females with a mean age of 17.8 years, clinically diagnosed with BP were included in the study. Cephalometric parameters were hand traced on lateral cephalometric radiographs and measurements recorded for evaluation and comparison to norm values used for this population group to determine the features that both males and females present with.

Results

Characteristic pre-treatment dental features of the sample included maxillary incisors that were proclined and protruded with resultant decreased interincisal angle, mandibular incisors which were favourably positioned. Skeletal features included retrognathic jaws (maxilla to a greater degree) resulting in a mild to moderate Class III skeletal pattern but with females exhibiting a smaller ANB angle indicating a greater tendency for a Class III skeletal pattern. The skeletal growth pattern was vertically directed with an average anterior facial height ratio.

Conclusion

The findings indicate that most BP patients in this South African Black population presented with dentoalveolar protrusion, retrognathic jaws and a mild to moderate skeletal Class III pattern.

Keywords

Bimaxillary protrusion, Black South Africans, facial profile, facial aesthetics

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INTRODUCTION

Bimaxillary Protrusion (BP) is a well reported form of malocclusion characterised by protrusive incisors with resultant protrusion of the lips. As a result of the anaesthetic facial appearance brought about by this increased procumbency, many people seek orthodontic care in order to reduce this procumbency.[1,2,3] A review of the literature reveals that grey areas exist regarding the diagnosis of bimaxillary protrusion. It is not clear whether the facial protrusion is solely due to incisor proclination, protrusion or both and whether there is also involvement of the dentoalveolar bases.[4]

Culture, ethnicity, society as well as personal preferences all play an important role in determining whether individuals will seek orthodontic treatment or not. The interpretation of the many published studies performed on the Caucasian5 and African American populations[6,7] must be done with caution as they may not be applicable in a South African population, comprising of ethnic groups that differ in cultural and social dictums. Beukes, Dawjee and Hlongwa[8] and Dawjee, Becker and Hlongwa[9] determined what Black South Africans regard as a pleasing and acceptable facial profile. It was determined that the need for therapeutic intervention was dependent on the severity of the incisor protrusion, the ability of the patient to close the lips without strain and the patients desire to modify their appearance.

The aim of the study was to perform cephalometric radiographic analyses of dental and skeletal structures of a sample of South African patients presenting with BP in order to identify characteristic features.

METHODOLOGY

Sample size and selection

The research project was approved by the Sefako Makgatho University Research Ethics Committee (SMUREC) prior to commencement (Protocol number: SMUREC/D/125/2018: PG).

This was a descriptive retrospective record-based study. The sample consisted of 67 patients divided into 28 males and 39 females with a mean age of 17.8 years. The sample size was found to be sufficient according to the Central Limit Theorem and comparative analysis of similar published studies.[10,11] The study population consisted of individuals who visited the department of orthodontics

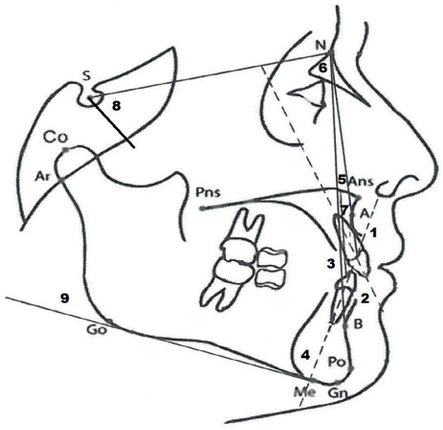

Figure 1: Angular measurements 1) UI-NA, 2) LI-NB, 3) UI-LI, 4) LI-MP, 5) SNA, 6) SNB, 7) ANB, 8) Y-Axis, 9) SN-MND

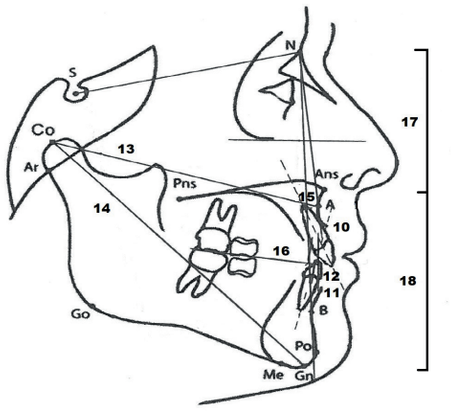

Figure 2: Linear measurements 10) UI-NA, 11) LI-NB, 12) LI-APg, 13) CO-A, 14) CO-GN, 15) Convexity, 16) WITS, 17) UFH, 18) LFH

at the Sefako Makgatho Health Sciences University and were clinically diagnosed with bimaxillary protrusion. These were patients who presented with varying degrees of lip separation at rest, mentalis strain, gummy smile or anterior open bites. Standard pre-treatment lateral cephalometric records of patients treated from 1 January 2015 to 31 December 2020 were visually assessed by the principal researcher and again re-assessed by the supervisor and only those of superior diagnostic quality were selected for the study. Lateral cephalometric radiographs of patients with craniofacial abnormalities, a history of trauma, prior orthodontic treatment, orthognathic or cosmetic surgery were excluded from the study.

Cephalometric analysis

A standardized method of cephalometric measurement using a fine-point 4H pencil and lead acetate paper was carried out by the researcher. All lateral cephalograms were traced as shown in (Figures 1 & 2) and parameters indicated (Table I) were measured. Intra-reliability measurement test was performed by the principal researcher as well as an inter-reliability test by the supervisor at two different time intervals where 10 lateral cephalograms were chosen at random and were re-traced and re-measured to determine the reliability of data. Strict adherence to inclusion and exclusion criteria was adhered to in order to avoid sampling bias. Measurement bias was minimised by tracing no more than 10 cephalograms at a time to avoid operator fatigue.

Statistical analysis

All statistical analyses were performed on the SAS (SAS Institute Inc. Carey. NC, USA), release 9.4 running under Microsoft Windows. All statistical tests were two-sided and p values ≤ 0.05 were considered significant. Where

Table I: Dental measurements used for analysis

Parameter	Description
	Linear
UI-NA	Relative position of maxillary incisor teeth to the N-A line
LI-NB	Relative position of mandibular incisor teeth to the N-B line
LI- APg	Relative position of mandibular incisor teeth to the A-Pg line
	Angular
UI-NA	Relative angular relationship of maxillary incisor teeth
LI-NB	Relative angular relationship of mandibular incisor teeth
UI-LI	Angle between the maxillary and mandibular incisor axis posteriorly
LI-MP	Relative angular relationship of mandibular incisor teeth

Skeletal measurements used for analysis

Parameter	Description
	Linear
CO-A	Effective midface length (McNamara)
CO-GN	Effective mandibular length (McNamara)
WITS	Linear distance between projection on point A & Point B on the functional occlusal plane
Convexity	Distance from point A at 90 degrees to N-Pg line
LFH	Vertical distance from ANS to Menton
	Angular
SNA	Anteroposterior position of maxilla
SNB	Anteroposterior position of mandible
ANB	Differences between SNA and SNB
Y-Axis	Direction of growth
SN-MND	Vertical relationship of the mandible

applicable, measurements from the study were compared to normative values (Table II) using the t-test from relevant literature sources.

The data analysis included comparisons of gender and race, and comparisons of subgroups of patients was performed if there was any clinical interest. Where applicable 95% confidence intervals were calculated.

RESULTS

Characteristic features of bimaxillary protrusion

Table III illustrates the differences in the dental and skeletal variables in a sample of South African black patients with BP when compared to the established norms.

Dental analysis revealed maxillary incisor protrusion (UI-NA: 10.3 ±3.19 mm) and proclination (UI-NA: 30.8±8.12°). The lower incisors displayed no significant difference from the accepted norms in terms of both their linear (LI-NB: 37.7±7.17mm; LI-Apg: 8.1±2.65mm) and angular positions (LI-NB: 37.7 ±7.17°; LI-MP: 99.0±13.75°). The maxillary and mandibular incisors demonstrated proclination in relation to each other (UI-LI: 107.7±11.98°).

Skeletal characteristics showed a decrease in both the effective midfacial length (CO-A: 83.4±5.21mm) and effective mandibular length (CO-GN: 107.3±5.92mm). The sagittal positional relationship of both the maxilla and mandible in relation to the cranial base was retrognathic (SNA: 82.7±4.90°) (SNB: 78.3±3.86°), with an ANB angle which was decreased (4.2 ±2.87°; p= 0.03), indicating a mild Class III skeletal pattern. In relation to the norm values, the convexity (convexity: 4.3 ±2.46mm) and the WITS values (WITS: -2.9±3.91mm) displayed no statistical differences within the BP sample.

In terms of the vertical relationships the sample exhibited a slight vertical growth pattern according to the Downs analysis (Y-Axis: 70.9±4.43°) with a slight decrease in both the UFH and LFH (UFH: 46.3±3.61mm); LFH: 66.1±5.15mm), although in a ratio which is in line with harmonious relationship.

Tables IV and V compare the cephalometric measurements of males and females with BP to the norms. The characteristic features of BP encountered in the whole sample were the same in both males and females, with the only notable difference in the ANB angle. The male sample revealed that there was no statistically significant difference to the norm in contrast to females which exhibited a significant decrease in the ANB angle (p=0.039)

DISCUSSION

CHARACTERISTIC FEATURES OF BIMAXILLARY PROTRUSION

The facial profiles of patients with BP appear to present with an increased convexity due to the more anterior placement of the skeletal, dental and soft tissue structures which

Table II: Cephalometric Normative values (Grimbeek, Cumber and Seedat, 1987[12]; Dawjee, 2010[13]; Wanjau, Khan and Sethusa, 2019)[14]

PARAMETER	CAUCASIAN		SA BLACKS	
	MALE	FEMALE	MALE	FEMALE
DENTAL				
		Linear		
UI-NA	4mm	4mm	7mm	7mm
LI-NB	4mm	4mm	10mm	10mm
LI- APg	0.5-1mm	0.5-1mm	7-8mm	7-8mm
		Angular		
UI-NA	22°	22°	22°	22°
LI-NB	25°	25°	38°	38°
UI-LI	131°	131°	116°	116°
LI-MP	90°	90°	102°	102°
LI-MP	90°	90°	102°	102°
SKELETAL				
		Linear		
CO-A	99.8mm	99.8mm	91mm	91mm
CO-GN	132.3mm	132.3mm	117mm	117mm
WITS	0(±1)mm	0(±1)mm	-1-2mm	-1-2mm
Convexity	2±2mm	2±2mm	4mm	4mm
UFH	50	50	50	50
LFH	70	70	70	70
		Angular		
SNA	82(±2)°	82(±2)°	87°	87°
SNB	80°	80°	82°	82°
ANB	2(±2)°	2(±2)°	5°	5°
Y-Axis	59°±6°	59°±6°	66°-68°	66°-68°
SN-Mand	32°	32°	32°-34°	32°-34°

Table III: Comparisons of cephalometric measurements in a South African sample with BP to norm values

Variable	Norm	n	Mean (±SD)	95% CI for true mean	p value#
Dental					
UI-NA (mm)	7	67	10.3 (±3.19)	9.5 – 11.1	<0.001*
LI-NB (mm)	10	67	10.5 (±2.70)	9.9 – 11.2	0.119
LI-Apg (mm)	7-8	67	8.1 (±2.65)	7.4 – 8.7	0.782
UI-NA (°)	22	67	30.8 (±8.12)	28.8 – 32.8	<0.001*
LI-NB(°)	38	67	37.7 (±7.17)	35.9 – 39.4	0.700
UI-LI (°)	116	67	107.7(±11.98)	104.8 – 110.6	<0.001*
LI-MP (°)	102	67	99.0 (±13.75)	95.7 – 102.4	0.083
Skeletal					
CO-A (mm)	91	67	83.4 (±5.21)	82.1 – 84.7	<0.001*
CO-GN (mm)	117	67	107.3 (±5.92)	105.8 – 108.7	<0.001*
Sagittal relation					
WITS (mm)	-3 to-1	67	-2.9 (±3.91)	-3.8 to -1.9	0.828
SNA (°)	87	67	82.7 (±4.90)	81.5 – 83.9	<0.001*
SNB (°)	82	67	78.3 (±3.86)	77.3 – 79.2	<0.001*
ANB (°)	5	67	4.2 (±2.87)	3.5 – 4.9	0.030*
Convexity (mm)	4	67	4.3 (±2.46)	3.7 – 4.9	0.324
Vertical relation					
Y-Axis (°)	66	67	70.9 (±4.43)	69.9 – 72.0	<0.001*
SN-Mand (°)	32-34	67	35.0 (±5.61)	33.6 – 36.3	0.168
UFH (mm)	50	67	46.3 (±3.61)	45.4 – 47.2	<0.001*
LFH (mm)	70	67	66.1 (±5.15)	64.8 – 67.3	<0.001*

*p values calculated by the t test

Interpretation

1. The mean values in the green coloured blocks are all significantly greater than the norm values (all p values are <0.001). The norm values are also all smaller than the lower limits of the 95% confidence intervals.
2. The mean values in the orange coloured blocks are significantly smaller than the norm values (all p values are <0.001 and =0.030 in one case). The norm values are also all greater than the upper limits of the 95% confidence intervals.
3. The mean values in the blue coloured blocks do not differ significantly from the norm values (all p values are >0.05). The norm values also overlap with the 95% confidence intervals.

make up the midface[5]. There have been only a few older studies investigating the skeletal and dental cephalometric features of individuals with well-balanced faces revealing the characteristics of normal occlusion among the South African black population.[12,14,15,16,17] This study can be considered one of a few studies on BP in a South African sample revealing the unique skeletal and skeletal features.

Dental features

Flaring of the upper and lower incisors is as a common finding amongst black population groups[6,16,18,19] and was similarly noted in this study, particularly more in relation to the maxillary teeth. The maxillary incisors were significantly more proclined and protrusive when compared to the norms established for this population group. The lower incisors aligned themselves more closely to the accepted angular and positional relationships with no real proclination or protrusion present. Findings which are all in conflict to conclusions drawn from studies performed on the Zimbabwean population[2] which reported maxillary incisors that were retroclined and mandibular incisors that were severely proclined. The inter-incisal angle (UI-LI: 107.7±11.98°) was found to be more than that reported for African Americans[19] and the Sudanese[20] with less proclination experienced in the South African context. In contrast, the values reported for Caucasians[5], the Taiwanese[21] and the Thai[11] amount to the sample exhibiting a greater degree of proclination and protrusion.

Skeletal features

A diagnosis of bimaxillary skeletal protrusion is made when both the maxilla and mandible are found to be in protruded positions in relation to the cranial base.[22] The results from this study on a sample of South Africans with features of BP excluded the presence of any skeletal protrusion, as they displayed no prognathism of the both the maxilla and mandible. Remarkably the maxilla was found to be retrognathic (SNA: 82.7±4.90°) as was the mandible (SNB: 78.3±3.86°), albeit to a slightly lesser degree.

In terms of the ANB angle, Jacobson in 1975 determined that the ANB angle may be affected by the anatomical position of the Nasion, rotation of the skeletal bases (jaws), lower anterior facial height or the degree of prognathism

Table IV: Comparisons of cephalometric measurements in a South African male sample with BP to norm values

Variable	Norm	n	Mean (±SD)	95% CI for true mean	p value#
Dental					
UI-NA(mm)	7	28	9.5 (±3.36)	8.2 – 10.7	0.001*
LI-NB (mm)	10	28	10.5 (±2.58)	9.5 – 11.5	0.313
LI-Apg (mm)	7-8	28	8.0 (±2.80)	6.9 – 9.1	1.000
UI-NA (°)	22	28	29.3 (±8.43)	26.1 – 32.4	<0.001*
LI-NB (°)	38	28	37.3 (±8.38)	34.2 – 40.5	0.672
UI-LI (°)	116	28	109.1(±13.98)	103.8 – 114.4	0.015*
LI-MP (°)	102	28	96.8 (±19.57)	89.4 – 104.1	0.167
Skeletal					
CO-A (mm)	91	28	84.1 (±5.46)	82.1 – 86.2	<0.001*
CO-GN (mm)	117	28	108.2 (±6.19)	105.9 – 110.5	<0.001*
Sagittal relation					
WITS (mm)	-3 to-1	28	-3.0 (±4.69)	-4.8 to -1.3	0.968
SNA (°)	87	28	83.5 (±5.23)	81.5 – 85.4	0.001*
SNB (°)	82	28	79.1 (±3.92)	77.6 – 80.5	<0.001*
ANB (°)	5	28	4.4 (±3.30)	3.1 – 5.6	0.312
Convexity (mm)	4	28	4.4 (±2.79)	3.3 – 5.4	0.463
Vertical relation					
Y-Axis (°)	66	28	70.5 (±4.86)	68.6 – 72.3	<0.001*
SN-Mand (°)	32-34	28	34.2 (±5.48)	32.1 – 36.2	0.864
UFH (mm)	50	28	46.6 (±3.56)	45.2 – 47.9	<0.001*
LFH (mm)	70	28	66.2 (±6.08)	64.0 – 68.5	0.003*

*p values calculated by the t test

Interpretation

1. The mean values in the green coloured blocks are all significantly greater than the norm values (all p values are =0.001 or <0.001). The norm values are also all smaller than the lower limits of the 95% confidence intervals.
2. The mean values in the orange coloured blocks are significantly smaller than the norm values (p values are 0.015, <0.001 and 0.003 or =0.001). The norm values are also all greater than the upper limits of the 95% confidence intervals.
3. The mean values in the blue coloured blocks do not differ significantly from the norm values (all p values are >0.05). The norm values also overlap with the 95% confidence intervals.

that the jaws possess. The ANB angle in this situation was slightly decreased at 4.2 ±2.87° (p = 0.03) suggesting a mild Skeletal Class III pattern given the applicable norm (5°). This finding may be attributed to a mismatch of the relationship between the SNA and SNB which are reduced, but with a SNB angle which is reduced to a lesser degree. The Zimbabwean[2] and Caucasian[5] populations featured a Class II skeletal pattern which presented with an increase in the ANB angle attributed to a downward and backward rotation of the mandible, except in the Zimbabwean study[2] which implicated a mismatch in a small SNB angle, to a larger SNA angle. A notable feature among Asian population groups is the presence of a decreased ANB, translating to Class III skeletal pattern[11,21] as is observed in this sample group. The presence of a mild Skeletal Class III pattern makes these patients ideal candidates for consideration of camouflage treatment.[23]

The presence of growth in a slightly more vertical direction is indicated by an increased value of the Downs Analysis (Y-Axis: 70.9±4.43°) and suggests that individuals with BP tend to be hyperdivergent. These findings are in agreement with those studies performed on Afro-Caribbeans,[24] Sudanese[20] and Caucasian populations5. However, these findings were inconsistent with the horizontally directed growth pattern found in Zimbabweans,[2] Arabs[25] and Asians.[11] The UFH (46.3±3.61mm) and LFH (66.1±5.15mm) although slightly reduced, remains in a ratio which is in line with harmonious relationship. The presence of only a slightly vertical growth pattern in addition may have significant positive effects. Orthodontic treatment with fixed appliances usually tends to have extrusive effects[23] and can assist with the correction of the mild Class III skeletal pattern as the mandible rotates downwards and backwards during treatment.

In summary an increased facial convexity in South African black patients was a result of bimaxillary dentoalveolar protrusion. There was no element of skeletal prognathism from either the maxilla or mandible. These patients also exhibited a slightly increased vertical direction of growth with males and females displaying very similar cephalometric features except a decrease in the ANB angle in females indicating a tendency to a more Class III skeletal pattern.

CONCLUSION

When compared to cephalometric norms established for the South African Black population, the characteristic features that BP patients present with include:

- Proclination and protrusion of the maxillary incisors but favourably positioned and inclined mandibular incisors. This resulted in an increased interincisal angle.
- The maxilla and mandible are both retrognathic, however the maxilla to a greater degree than the mandible resulting in a mild Class III skeletal pattern.
- The presence of a slight vertically directed growth pattern with average anterior facial height ratios.
- All characteristic features of BP are the same in males and females, except that females exhibit a smaller ANB angle indicating a greater tendency for a Class III skeletal pattern.

These findings conclude that characteristic features of the South African Black population presenting with BP are unique and highlights the importance of knowing and understanding these unique features when diagnosing and planning treatment for this population group.

Table V: Comparisons of cephalometric measurements in a South African female sample with BP to norm values

Variable	Norm	n	Mean (±SD)	95% CI for true mean	p value#
Dental					
UI-NA (mm)	7	39	10.9 (±2.96)	10.0 – 11.8	<0.001*
LI-NB (mm)	10	39	10.5 (±2.83)	9.6 – 11.4	0.242
LI-Apg (mm)	7-8	39	8.2 (±2.57)	7.3 – 9.0	0.710
UI-NA (°)	22	39	31.9 (±7.82)	29.4 – 34.4	<0.001*
LI-NB (°)	38	39	38.0 (±6.26)	35.9 – 40.0	0.919
UI-LI (°)	116	39	106.6(±10.38)	103.3 – 110.0	<0.001*
LI-MP (°)	102	39	100.7 (±7.05)	98.4 – 102.9	0.254
Skeletal					
CO-A (mm)	91	39	82.9 (±5.04)	81.3 – 84.5	<0.001*
CO-GN (mm)	117	39	106.6 (±5.71)	104.8 – 108.4	<0.001*
Sagittal relation					
WITS (mm)	-3 to-1	39	-2.8 (±3.29)	-3.8 to -1.7	0.700
SNA (°)	87	39	82.1 (±4.63)	80.6 – 83.6	<0.001*
SNB (°)	82	39	77.7 (±3.77)	76.5 – 78.9	<0.001*
ANB (°)	5	39	4.1 (±2.55)	3.3 – 4.9	0.039*
Convexity (mm)	4	39	4.2 (±2.23)	3.5 – 4.9	0.522
Vertical relation					
Y-Axis (°)	66	39	71.3 (±4.12)	70.0 – 72.6	<0.001*
SN-Mand (°)	32-34	39	35.5 (±5.70)	33.7 – 37.3	0.106
UFH (mm)	50	39	46.1 (±3.67)	45.0 – 47.3	<0.001*
LFH (mm)	50	39	66.0 (±4.44)	64.6 – 67.4	<0.001*

*p values calculated by the t test

Interpretation

1. The mean values in the green coloured blocks are all significantly greater than the norm values (all p values are <0.001). The norm values are also all smaller than the lower limits of the 95% confidence intervals.
2. The mean values in the orange coloured blocks are significantly smaller than the norm values (p values are <0.001 and 0.003 and = 0.039 in one case). The norm values are also all greater than the upper limits of the 95% confidence intervals.
3. The mean values in the blue coloured blocks do not differ significantly from the norm values (p values are >0.05 and = 0.106). The norm values also overlap with the 95% confidence intervals.

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The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.