− ORIGINAL ARTICLE −

Comparative Cephalometric Study of Dentofacial Morphological Norms in Yemeni and Japanese Adult Males

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セファログラム分析によるイエメン人成人正常咬合者と日本人成人正常咬合者との顎顔面形態の比較

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Abstract : The aim of this study was to describe the dentofacial pattern of the Yemeni ethnic group, and to compare it with cephalometric standards of Japanese adults. Lateral cephalograms of 50 Yemeni men, normal occlusion, mean age 23.1 years, were analyzed. Student t-test was used to compare their means and SDs with standard values of similar Japanese adults. Significant racial differences were found. The anterior cranial base was significantly longer anteroposteriorly in the Yemeni subjects (YEM) than in the Japanese values (JPN). The maxilla and chin were significantly more protruded in YEM. Lower anterior face height was significantly greater in YEM, although the mandibular plane angle was significantly smaller in YEM. Maxillary and mandibular lengths were significantly greater in YEM than in JPN, the gonial angle was significantly smaller in YEM. Point B was significantly more posterior in relation to point A (Wits analysis) in YEM, and their upper incisors were significantly less proclined. This study reveals significant racial differences in cephalometric measurements, supporting the idea that a single set of standards is not applicable to all racial groups, and suggesting that such racial differences must be taken into account during diagnosis and treatment planning.

抄録：この研究の目的は，イエメン人成人と日本人成人との顎顔面形態について比較検討することである。正常咬合を有するイエメン人男性50名（平均年齢23.1歳）を対象とし，対象者の顎顔面形態について側面セファログラムを用いて分析を行った。Student's t-testにより日本人成人の平均値との差の検定を行った結果，有意な差を認めた。

イエメン人では，日本人と比較し前頭蓋底距離が有意に長く，上顎とオトガイも有意に突出していた。また，イエメン人では下顎下縁平面角は有意に小さかったが，下顔面高は有意に長かった。

上顎骨長，下顎骨長はイエメン人で有意に長かったが，下顎角はイエメン人が有意に小さかった。さらに，イエメン人ではWits分析でB点はA点に対して有意に後方に位置し，上顎前歯の唇側傾斜の程度は小さかった。

これらのセファロ分析の結果から，イエメン人・日本人間の顎顔面形態には人種的な相違が認められ，矯正診断・治療方針の立案を行う際には平均値を画一的に応用するのではなく人種間の差を考慮する必要があることが示唆された。

1. Introduction

Successful diagnosis in orthodontics and orthognathic surgery involves gathering information from clinical examinations, plaster casts, photographs and cephalometric tracings. The advent of cephalometrics by Broadbent in 1931[1] first provided a valuable tool for the diagnosis and treatment planning of orthodontics and orthognathic surgery. Since that time, researchers have been seeking to define standard linear and angular measurements of the craniofacial complex, in order to be able to use such measurements in diagnosing and planning the treatment of malocclusion, as well as to disclose the areas and nature of dentofacial defects.

A standardized approach assumes that the goal of treatment is to approximate certain norms. Although differences exist in the viewpoints of various researchers as to the validity of cephalometric norms and their application in individual cases, researchers generally insist on the importance of certain norms for treatment planning. Many researchers in several countries have therefore sought to establish cephalometric norms for their compatriots. As a result of their efforts, such cephalometric analyses have become useful tools during diagnosis, evaluation and treatment planning for the patients undergoing either orthodontic treatment or orthognathic surgery.

The importance of keeping cephalometric norms relevant to particular age and ethnic groups is well known[2-5] ; as one set of standards cannot be used in the diagnosis and treatment of all populations. Numerous studies have therefore been conducted to determine the morphological variables for the craniofacial structures of different ethnic groups [2-17] . Most of these studies have confirmed that significant differences do indeed exist between such groups. One of the valuable tools used in comparing the craniofacial structures of different ethnic groups is Burstone's et al cephalometric analysis for Orthognathic Surgery (COGS)[18] . The COGS is especially adapted to the diagnosis and treatment planning of orthognathic surgery cases, because it is based largely upon linear measurements that can be referred to before and during surgery.

In Yemen, orthodontics is still a young branch of dentistry, but the number of Yemeni patients seeking orthodontic and orthognathic surgery both at home and abroad has been increasing. Therefore, a need has arisen for accurate and comprehensive orthognathic surgery norms for this specific population. However, to date there has been only one study by Farhan M[3] , which only determined orthodontic norms for Yemeni adults and compared them with Egyptian ones.

The aims of the present study were:

-To develop cephalometric orthognathic surgery norms that may be used as reference points in diagnosis and treatment planning for Yemeni adults.

-To investigate whether significant cephalometric differences exist between comparable Yemeni and Japanese population samples.

2. Subjects and Methods

This study was carried out on a sample of Caucasian Yemeni university students at Ibb University, Ibb city, and the University of Applied and Social Sciences, Sana'a city, Yemen. The first step of the selection process included clinical examinations and interviews (first author), to obtain subjects who satisfied the following criteria:

-Yemeni citizen with Yemeni ancestry

-Class I molar and canine relationships

-Normal overjet and overbite (1 - 2.5mm and 5%-20%[19] , respectively)

-Symmetrical face

-Absence of crowding

-No previous orthodontic, orthognathic, or prosthodontic treatments

-No craniofacial deformities or trauma

The subjects who met the above mentioned criteria were selected, after their consent to participate in this study was obtained. All procedures were approved by the Ibb University Institutional Review Board. From a survey of 1500 students, only 50 males and 7 females satisfied all of the above subject selection criteria, and because the number of females was too small [as a result of cultural and religious reasons]; these female subjects were not included in the present study.

Lateral cephalometric radiographs were taken on each of the 50 subjects in natural head position[20] with the teeth in maximum intercuspation, and lips in repose. The radiographs were taken at the Faculty of Dentistry, University of Sciences and Technology, Sana'a, Yemen, using a Gendex Orthoralix (SD2-1997,

Gendex Dental Systems, Milan, Italy) at 75-80 Kv, 10 mA/second. Lateral cephalograms of all subjects were traced and measured by hand on 0.003mm matte acetate paper (Yunipa, Kimoto, Tokyo, Japan). All landmarks were identified according to the definitions of Burstone et al[18]. Landmarks and angular and linear measurements are shown in Figures 1 to 4.

All cephalograms were traced and measured by the

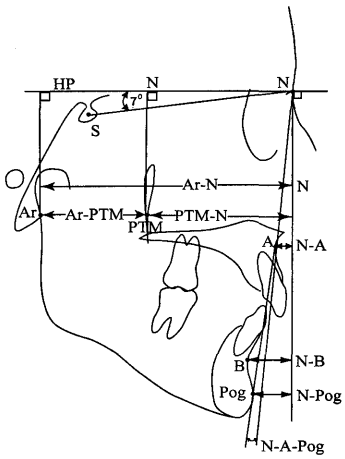

Figure 1. Cranial base and anteroposteriorly skeletal measurements

The horizontal plane (HP) line: A line through N 7 degrees clockwise from S-N.

Posterior cranial base (Ar-PTM): the horizontal distance between the two lines through Ar and PTM respectively, perpendicular to HP

Anterior cranial base (PTM-N): the horizontal distance between the two lines through PTM and N respectively, perpendicular to HP

Facial convexity (N-A-Pog): the acute interior angle formed by the intersection of lines N-A and A-Pog.

Maxillary protrusion (N-A): the horizontal distance between point A and N [projected on the line through N perpendicular to HP].

Mandibular protrusion (N-B): the horizontal distance between point B and N [projected on the same line as above].

Chin protrusion (N-Pog): the horizontal distance between point Pog and N [projected on the same line as above].

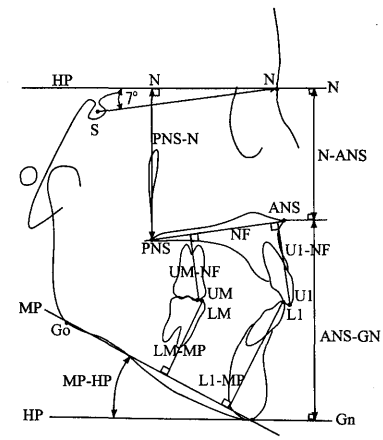

Figure 2. Vertically skeletal and dental measurements

Upper anterior face height (N-ANS): the distance from N to ANS

Lower anterior face height (ANS-Gn): the distance from ANS to GN that is measured perpendicular to HP

Upper posterior face height (PNS-N): the distance from HP to PNS

Mandibular plane angle (MP-HP): The angle formed between a line from Go and Gn and HP as it intersects Gn

Upper anterior dental height (UI-NF): the perpendicular distance from the incisal edge of the maxillary central incisor to NF.

Lower anterior dental height (LI-MP): the perpendicular distance from the incisal edge of the mandibular central incisor to MP.

Upper posterior dental height (UM-NF): the perpendicular distance from the maxillary first molar mesiobuccal cusp tip to NF

Lower posterior dental height (LM-MP): the perpendicular distance from the mandibular first molar mesiobuccal cusp tip to MP

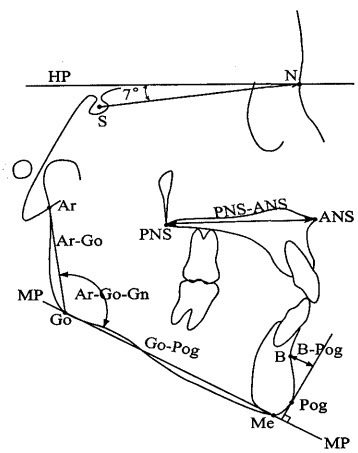

Figure 3. Maxillary and mandibular measurements

Maxillary length (PNS-ANS): the distance from PNS to ANS

Mandibular ramus length (Ar-Go): the distance from Ar to Go

Mandibular body length (Go-Pog): distance along MP from Go to the perpendicular projection of Pog

Chin depth (B-Pog): the perpendicular distance from point B to a line perpendicular to MP through Pog

Gonial angle (Ar-Go-GN): the obtuse angle formed by the ramal plane (Ar-Go) intersecting MP at Go.

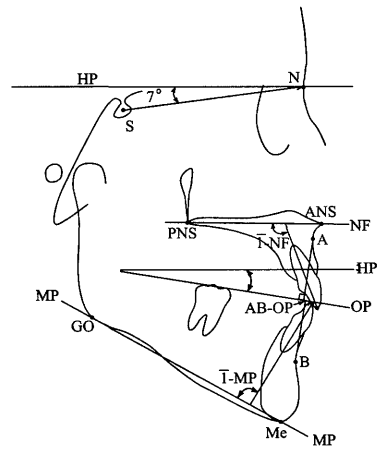

Figure 4 Dental relationships measurements

Occlusal plane angle (OP-HP): the angle formed between HP and the occlusal plane drawn through the buccal groove of the lower first permanent molar through a middle point between the incisal edges of the both central incisors in each respective arch.

Wits analysis (A-B to OP): the distance between the lines perpendicular to OP through points A and B respectively.

Upper incisor inclination (UI-NF): this angle formed by the intersection of a line drawn from the upper central incisal edge through the tip of its root to NF.

Lower incisor inclination (LI-MP): This angle constructed from a line drawn from the lower central incisal edge through the tip of its root to the point of intersection with MP.

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Statistics

Descriptive statistics, including means and SD values, were determined for the total sample of Yemeni males. These means and SDs, and corresponding Japanese male values obtained by Alcalde et al[2] were compared using Student's t-test, with the level of significance set at 0.05.

Methodological Error

An error analysis of landmark location was performed using 10 radiographs randomly selected from the 50 subjects; tracings for 10 radiographs chosen were performed twice at a 3-week interval, to determine the methodological error using Dahlberg's formula[21] .

Measurements	Dahlberg's Value
Ar-PTM	0.353
PTM-N	0.387
N-A-Pog	0.537
N-A	0.302
N-B	0.558
N-Pog	0.674
N-ANS	0.486
ANS-Gn	0.421
PNS-N	0.298
MP-HP	0.716
UI-NF	0.371
LI-MP	0.818
UM-NF	0.377
LM-MP	0.371
PNS-ANS	0.571
Ar-Go	0.394
Go-Pog	0.828
B-Pog	0.465
Ar-Go-Gn	0.644
OP-HP	0.858
A-B(OP)	0.459
U1-NF	0.474
LI-MP	0.873

Table 1 Methodological errors

3. Results

1. Methodological errors for Cephalometric tracings

The cephalometric tracing errors using Dahlberg's formula[21] were 0.298 - 0.828 for linear measurements and 0.474 - 0.873 for angular measurements. (Table 1)

2. Cranial base relationships (Table 2)

The anterior cranial base (PTM-N) was significantly longer in the anteroposterior dimension in the Yemeni group (YEM) than in the Japanese (JPN). However, the posterior cranial base (Ar-PTM) was not significantly different between the two groups.

3. Anteroposteriorly skeletal relationships

The only statistically significant difference was found in maxillary protrusion (N-A), that was greater in YEM (as indicated by the smaller negative value).

4. Vertical skeletal and dental relations

YEM showed significantly greater lower anterior face height (ANS-Gn), and a significantly smaller mandibular plane angle (MP-HP) than JPN. However, the other parameters were not significantly different between the two groups.

5. Maxillary and mandibular measurements

Maxillary length (PNS-ANS) and mandibular body length (Go-Pog) were significantly greater in YEM than in JPN, with the chin also significantly more prominent in YEM. On the other hand, the gonial angle (Ar-Go-Gn) was significantly less obtuse in YEM than in JPN.

6. Dental relationships

Using Wits analysis, point B was located significantly more posteriorly in YEM than in JPN in relation to point A. YEM also had significantly less proclined upper incisors (UI-NF) compared with JPN.

4. Discussion

The purpose of this study was first to establish cephalometric orthognathic surgery (COGS) norms for Yemeni adult males, and then to compare this data with Japanese norms[2] . The reason for conducting this comparison was that, both Yemen and Japan are located in Asian region, but morphological features appear to be different due to various reasons such as origin, environment etc. Previous studies related to cephalometric norms in Yemeni adults was limited to one study[3] which had used a sample of 50 adult males and developed cephalometric norms only for orthodontic application. Normal values for cephalometric orthognathic surgery (COGS) have not been available for Yemeni adults until now.

Although previous cephalometric studies have employed a variety of subject selection criteria, most of them have based their selection on Class I occlusion[2-6] , facial esthetics[22] or both[7, 8] . The selection

Skeletal/Dental Values	Measurement	Yemenis (N = 50) Mean	SD	Japanese (N = 98) ‡ Mean	SD	p-value
Cranial base measurements						
Posterior cranial base	Ar-PTM (mm)	37.6	2.5	37.6	2.9	NS
Anterior cranial base	PTM-N (mm)	53.9	3.2	51.6	3.7	***
Anteroposteriorly skeletal relations						
Facial convexity	N-A-Pog (degrees)	5.3	4.5	4.2	5.4	NS
Maxillary protrusion	N-A (mm)	-0.1	3.3	-2.0	4.8	***
Mandibular protrusion	N-B (mm)	-6.5	5.5	-7.9	7.4	NS
Chin protrusion	N-Pog (mm)	-5.7	6.5	-8.0	8.6	NS
Vertically skeletal and dental measurements						
Upper anterior face height	N-ANS (mm)	58.9	3.3	58.7	3.5	NS
Lower anterior face height	ANS-GN (mm)	70.8	4.7	68.8	5.0	*
Upper posterior face height	PNS-N (mm)	55.4	2.6	55.7	3.0	NS
Mandibular Plane angle	MP-HP (degrees)	22.9	5.1	25.2	5.5	**
Upper anterior dental height	UI-NF (mm)	29.9	2.8	30.1	2.9	NS
Lower anterior dental height	LI-MP (mm)	45.4	3.0	45.3	3.2	NS
Upper posterior dental height	UM-NF (mm)	26.6	2.5	25.9	2.4	NS
Lower posterior dental height	LM-MP (mm)	37.8	2.7	37.8	2.5	NS
Maxillary and mandibular measurements						
Maxillary length	PNS-ANS (mm)	58.6	3.2	54.6	3.8	***
Mandibular ramus length	Ar-Go (mm)	53.8	5.3	54.2	4.6	NS
Mandibular body length	Go-Pog (mm)	85.0	4.6	81.0	5.0	***
Chin depth	B-Pog (mm)	8.1	1.7	7.0	1.8	***
Gonial angle	Ar-Go-Gn (degrees)	115.4	5.6	118.0	6.1	**
Dental relationships measurements						
Occlusal plane	OP-HP (degrees)	8.8	2.9	8.8	5.0	NS
Wits analysis	A-B to OP (mm)	-0.5	2.6	0.4	3.2	*
Upper incisor inclination	UI-NF (degrees)	113.5	5.7	116.4	6.6	**
Lower incisor inclination	LI-MP (degrees)	97.1	6.4	95.1	6.7	NS

NS: Not significant, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

‡ J Oral Maxillofac Surg 56: 129, 1998

Table 2 Comparison of Burnstone et al analysis between Yemenis and Japanese

criteria of the present study was untreated Yemeni subjects having normal occlusion and intact dentition, in order to identify normative values that would be able to assist in the diagnosis and planning of orthodontic treatment or orthognathic surgery[2].

The comprehensive COGS analysis of Burstone et al[18] for hard tissue (Figures 1 through 4) was used in this study, as it is specific to orthognathic surgery and has often been used for such researches[2,4,5]. As for the subjects, they came from several regions of Yemen and were therefore quite representative of their country's ethnic group. Although our initial objective was to obtain a representative sample of Yemeni adults of both sexes, only males were finally included, due to the difficulty of obtaining a sufficient number of female subjects.

The present study reveals that the Yemeni sample (YEM) had a longer anterior cranial base (PTM-N) than the Japanese group (JPN), supporting previous investigations that compared the craniofacial morphology of Asians and Caucasians. According to a Japanese study by Ishii et al[23], several studies have reported that Asians have a reduced cranial base in Class I occlusion, [see also Nezu et al[24], Cooke and Wei[25], Deguchi et al[26], and Miyajima et al[7]], in subjects with Class II, [Ono et al[27], Ishii et al[28]] and Class III malocclusion as well [Ngan et al[29], Singh et al[30], Bukhary[31]]. The present finding enhances the suggestions of Fukui et al[32], in that the form of the cranial base could directly reflect certain genetic characteristics.

In this study, the maxilla was more protruded in YEM than in JPN. This supports the finding of Alcalde et al[2] who reported less maxillary protrusion in Japanese compared with Caucasian Americans. The maxillary length (PNS-ANS) was also significantly larger in YEM than in JPN, once again supporting the findings obtained by Alcalde et al[2], and Nezu et al[24], in that cephalometric differences exist between Japanese and other racial groups.

As for the mandible, the present study revealed that the chin was more prominent in YEM than in JPN. YEM also had longer mandibular body length (Go-Pog) than JPN, which may be due to more bony chin projection in YEM. Furthermore, the results obtained might indicate that YEM had more anterior mandibular growth pattern than JPN, suggested by their smaller gonial angles (Ar-Go-Gn) and mandibular plane angles (MP-HP) compared with JPN. These results are in line with the findings of the previous study carried out on Yemenis[3] and these racial features are also supported by comparative studies between Japanese and Caucasian having Class I occlusion[2, 7, 24] . Masaki[33] has also reported that there is anteroposterior coordination between the more posterior position of the maxilla and a backward rotation of the mandible in Japanese groups, indicated by a more retrusive maxilla and steeper mandibular plane angle.

It might be interesting to note that these racial features of Yemenis make for generally easier orthodontic/orthognathic treatment than those of Japanese patients.

Concerning the craniofacial vertical relationship, the present study showed that there was no significant difference between YEM and JPN as to upper anterior face height (N-ANS). This finding differs from the results obtained by Alcalde et al[2] , that Japanese had a larger upper anterior face height than Caucasian Americans. On the other hand, the lower anterior face height was significantly larger in YEM than in JPN.

As for the anteroposterior jaw relationship, Wits analysis indicated that point B was found to be significantly more posterior in relation to point A in YEM than in JPN. The present value was -0.5 mm, which was close to the value obtained from Saudi adult males (-1.06mm) who have had similar ethnic background[6] . On the other hand, -0.5 mm markedly differs from that obtained by Farhan (2.9 mm) for Yemeni adult males[3] , which may be due to our differing subject inclusion criteria. The Yemeni subjects in Farhan study[3] included minor crowding, acceptable Class I molar relationship, and no mention to overbite and overjet, but the all subjects in the present study had no crowding and Class I.

In comparison with the dental relationship of JPN, YEM displayed significantly less proclined upper incisors in relation to their corresponding skeletal bases, which is in agreement with the results obtained by Engel et al[34] and also reflects the results obtained by Farhan[3] , who reported less protrusive upper incisors in Yemenis than in Egyptians. Finally Shalhoub et al[6] , in a study on Saudi Arabian adults, reported that upper incisor inclination in males was 115.0 degrees, which closely corresponds to our present finding of 113.5 degrees.

5. Conclusion

A set of orthognathic surgery norms for Yemeni adult males has now been developed. As these norms differed significantly in several respects from Japanese norms, it is therefore apparent that orthognathic surgery norms differ according to ethnic group, due to each group's genetic characteristics. It now seems abundantly clear that cephalometric standards for one ethnic group are unsuitable for diagnosis and treatment planning for another group. The results of this study will hopefully be a useful reference for Yemeni orthodontists and maxillofacial surgeons treating Yemeni men, and contribute to more satisfactory diagnosis and treatment planning for them. However, further studies including both larger numbers of Yemeni subjects in general and female subjects in particular are still needed.

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