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# FACIAL PROPORTIONS IN DIFFERENT MANDIBULAR ROTATIONS IN CLASS I INDIVIDUALS

Shaghaf Bahrou \* | Abed Alkarim Hasan \*\* | Fadi Khalil \*\*\*

## Abstract

The aims of this study were to evaluate facial proportions in different types of mandibular rotation using various parameters, to explore gender dimorphism within each type and to evaluate the correlation between the mandibular rotation measurements and the facial proportions.

Lateral cephalograms of a total of 62 class I subjects (30 males and 32 female), aged between 18-25 years, were studied. The sample was divided into forward, normal, and backward rotation subgroups. Nine soft tissue facial proportions and five skeletal proportions were measured on lateral cephalometric radiographs. The facial proportions data were analyzed using independent sample Student t-test and Pearson correlation analysis.

The backward rotation subjects showed the lowest value for the proportion of total posterior facial height (TPFH) and total anterior facial height (TAFH) and proportion of lower posterior facial height (LPPFH) and TPFH and the highest value for the proportion of  $Sn-Pn_{\leftrightarrow}/Stms-Sn_{\uparrow}$ , while forward rotation subjects exhibited the lowest value for proportion of upper posterior facial height (UPFH) and TPFH.

Gender dimorphism was recorded; males showed higher value for the proportion of TPFH and TAFH, as well as for the proportion of  $Sn-Me'/G-Me'$  and  $Me'-Stmi/Me'-Sn$  in the backward rotation group.

All the skeletal facial proportions were found correlated with mandibular rotation measurements (NS-GoMe, B, FH-GoMe, Bjork) while only the soft tissue proportion for  $G-Sn/Sn-Me'$ ,  $Sn-Me'/G-Me'$  and  $G-Sn/G-Me'$  were correlated with mandibular rotation measurements.

The soft tissue drape particularly facial vertical dimensions are influenced by the underlying skeletal vertical pattern.

**Keywords:** Mandibular rotation - backward rotation - forward rotation - facial proportions.

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# PROPORTIONS FACIALES EN CAS DE ROTATIONS MANDIBULAIRES DIFFÉRENTES CHEZ DES INDIVIDUS EN CLASSE I

## Résumé

Les objectifs de cette étude étaient d'évaluer les proportions du visage dans différents types de rotation mandibulaire en utilisant différents paramètres, d'explorer le dimorphisme sexuel dans chaque type et d'évaluer la corrélation entre les mesures de la rotation de la mandibule et les proportions du visage.

Des céphalogrammes de profil d'un total de 62 sujets de classe I (30 hommes et 32 femmes), âgés de 18-25 ans, ont été étudiés. L'échantillon a été divisé en 3 groupes suivant le type de rotation mandibulaire.

Les données sur les proportions du visage ont été statistiquement évaluées à l'aide du test de Student et de l'analyse de corrélation de Pearson.

Les sujets présentant une rotation mandibulaire postérieure ont montré la valeur la plus faible pour la proportion « TPFH » et « TAFH » et la proportion de « LPPFH » et « TPFH », la valeur la plus élevée pour la proportion de «  $Sn - Pn_{\leftrightarrow}/STM - Sn_{\uparrow}$  », alors que pour les sujets présentant une rotation antérieure, la valeur de la proportion de « UPFH » et « TPFH » était la plus faible.

Le dimorphisme sexuel a été enregistré; les hommes présentant une rotation mandibulaire postérieure ont montré des valeurs plus élevées du rapport « TPFH » et « TAFH », ainsi que du rapport de  $Sn-Me'/G-Me'$  et  $Me'-Stmi/Me'-Sn$ .

Le drapé des tissus mous, en particulier les dimensions verticales du visage, est influencé par le modèle vertical squelettique sous-jacent.

**Mots-clés:** rotation mandibulaire – proportions faciales.

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## Introduction

Both soft tissue outline and skeleton determine facial harmony and balance. Facial esthetics is one of the main goals of orthodontic treatment and increased emphasis has been placed on it in recent years by both patients and orthodontists [1, 2].

The soft tissue profile has been studied extensively in orthodontics, primarily from lateral cephalometric radiographs, under the assumption that the form of the soft tissue outline largely determines the esthetics of the whole face [3].

Several investigators have noted that soft tissue behaves independently from the underlying skeleton [4, 5] whereas other researches have displayed that soft tissues are a major factor in determining a patient's final facial profile [6-9].

Facial proportion was defined as the comparative relation of facial elements in profile [10].

Most of researchers have long focused on antero-posterior balance, probably spurred by the widespread use of Angle's classification. Over the years, however, research and clinical experience have revealed the close interdependence of facial proportions in the three space dimensions [11].

In 1942, Thompson and Brodie [12], after performing measurements on radiographs of 50 adults and 300 dry skulls, concluded that nasal height (nasion-anterior nasal spine) accounts for 43% of the total facial height (nasion-gnathion).

Moreover, Wylie and Johnson [13] in 1952 studied 171 patients and found that in harmonious individuals, total facial height (TFH) is divided into 45% of nasal height (anterior nasal spine) and 55% of dental height (anterior nasal spine-chin), i.e., upper facial height (UFH) and lower facial height (LFH), respectively.

Later, in 1964, Schudy [14] examined cephalometric radiographs of 270 subjects, including both retrognathic and prognathic individuals with normal growth pattern. The results indica-

Sex	Subjects			
	Forward rotation	Normal rotation	Backward rotation	Total
Male	13	9	8	30
Female	9	11	12	32
Total	22	20	20	62

Table 1: Subjects distribution according to sex and mandibular rotation.

ted that UFH varied very little between the three facial types, even though it was 2 mm higher in the prognathic group. LFH accounted for 56% of TFH (nasion-chin) in the group with normal growth pattern, 59.5% in the retrognathic group and 54.1% in the prognathic group.

Before the advent of cephalometric radiography, anthropometric measures were frequently employed to help establish facial proportions [15]. However, this method has limitations since soft tissue compressibility can lead to errors during measurement [16].

When the aluminum filter was introduced in cephalometric radiographs [17], soft tissue measuring became part and parcel of cephalometric analysis. This allowed the study of the dento-skeletal profile since it was believed that certain hard tissue abnormalities could be masked or even heightened by the soft tissues. Soft tissue profile does not always follow skeletal profile as it differs from the latter in some areas [18]. This is due to a wide variability in soft tissue thickness [18] which renders inadequate the exclusive use of hard tissue analysis [6, 8].

Thus, evaluation of facial proportions and aesthetics should be conducted during clinical examination and the findings should be compared with cephalometric radiographs and photographs [15].

According to Margolis [19] one should focus on the proportions of the face. In light of the fact that many authors have proposed different methods to assess the facial proportions [20], this study aimed to:

1) Investigate the variation in facial proportions in different mandibular

rotation groups in a sample of adults with Class I normal occlusion;

2) To explore the gender dimorphism within each group of facial type;

3) To evaluate the correlation between the mandibular rotation and facial proportions in males and females.

## Materials and Methods

The sample of this study consisted of 62 adults (30 males and 32 females) aged 18–25 with class I normal occlusion. The selection criteria of the sample were as follows:

1. Full set of permanent teeth in both jaws excluding the third molars.
2. Angle's class I molar relationship.
3. Class I according to ANB (0-4).
4. No significant medical history and no history of facial trauma.
5. No history of orthodontic treatment or maxillofacial surgery or excessive restorative dentistry.

A lateral cephalogram was taken for each subject under rigidly standardized conditions with the mandible in centric occlusion. The 62 subjects were divided into three groups according to mandibular rotation (forward, normal and backward) based on an evaluation of the following skeletal parameters [21]:

1. The inclination of the mandibular plane relative to the Frankfort horizontal plane.
2. The inclination of the mandibular plane relative to the anterior cranial base.

The first parameter is based on anatomical landmark, while the second parameter involves a plane of orienta-

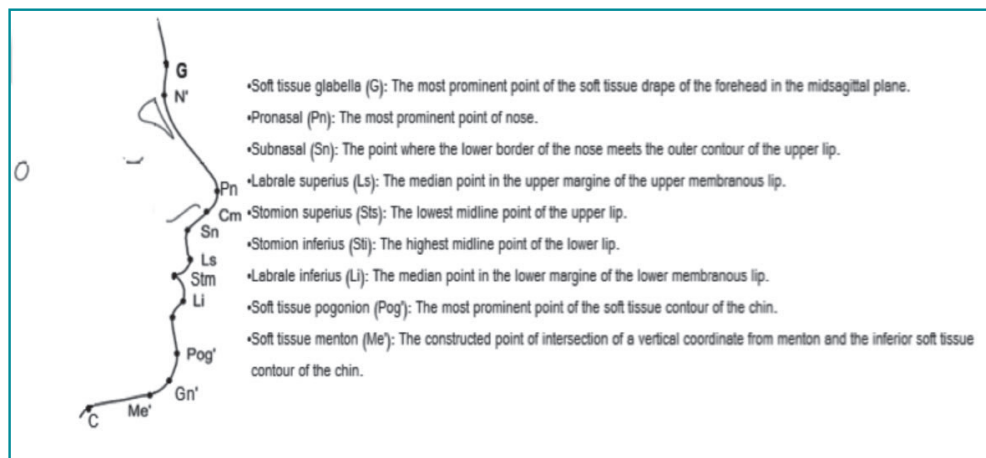


Fig. 1: Soft tissue landmarks determined on cephalograms [2223-].

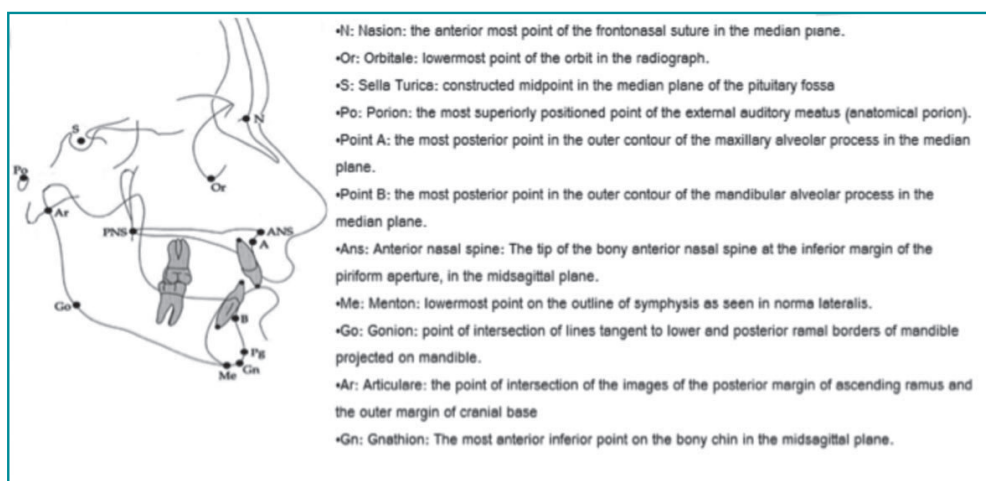


Fig-2: Skeletal landmarks determined on cephalograms [24].

tion. This approach insures that neither anatomic variation nor inaccurate orientation would influence ranking of the cases. For each of these parameters, all subjects were rank ordered and divided into 3 groups as described in table 1.

Specific soft tissue landmarks (Fig. 1) and cephalometric points (Fig. 2) were identified on each cephalogram.

Based on these landmarks, 18 facial proportions (5 skeletal and 9 soft tissues) were constructed. The following skeletal vertical linear measurements were recorded according to Schudy's analysis [14] (Fig. 3):

-Total anterior facial height (TAFH): Linear distance between nasion (N) and menton (Me).

-Upper anterior facial height (UAFH): Linear distance between N and ANS (perpendicular projection of anterior nasal spine in line N-Me).

-Lower anterior facial height (LAFH): Linear distance between ANS and Me.

-Total posterior facial height (TPFH): Linear distance between sella (S) and gonion (Go).

-Upper posterior facial height (UPFH): Linear distance between S and Ar (perpendicular projection of articular (Ar) in line S-Go).

-Lower posterior facial height (LPFH): Linear distance between Ar and Go.

1-UAFH/TAFH (N-ANS/N-Me): Proportion of UAFH and TAFH.

2-LAFH/TAFH (ANS-Me/N-Me): Proportion of LAFH and TAFH.

3-UPFH/TPFH (S-Ar/S-Go): Proportion of UPFH and TPFH.

4-LPFH/TPFH (Ar-Go/S-Go): Proportion of LPFH and TPFH.

5-TPFH/TAFH (S-Go/N-Me): Proportion of TPFH and TAFH.

The following soft tissue vertical linear measurements were recorded (Fig. 4):

-Vertical height ratio G-Sn/Sn-Me'.

-Vertical lip-chin ratio Sn-Stms/Stmi-Me'.

-Lower vertical height-depth ratio Sn-Gn'/C-Gn' according to Legan and Burstone analysis [5].

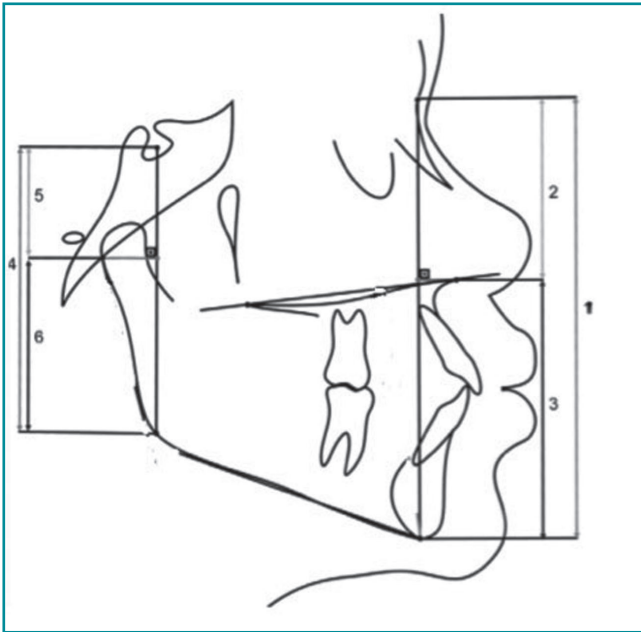


Fig. 3: Measurements from various analyses: Wylie and Johnson [13]: 1- TAFH; 2- UAFH; 3- LAFH. Siriawat and Jarabak [25]: 4- TPFH; 5 - UPPH; 6 - LPPH. Gebeck and Merrifield [2627-].

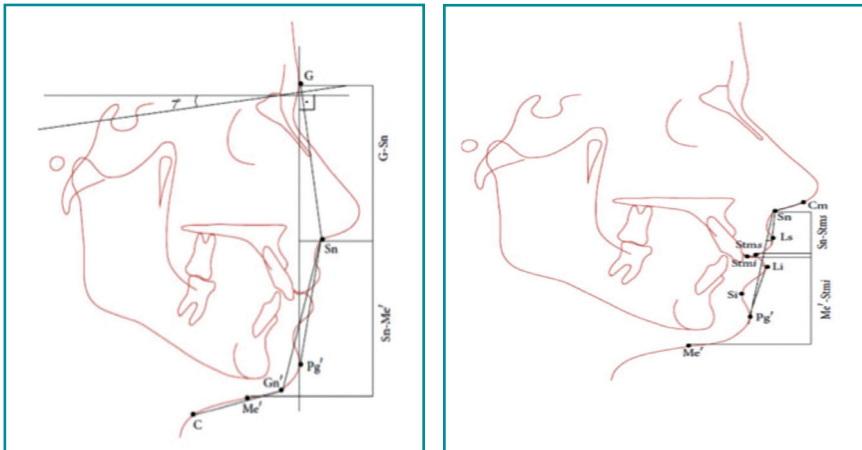


Fig. 4: Soft tissue facial proportions: Horizontal reference plane (HP), constructed by drawing a line through nasion (N) 7° up from S-N line.  
1) lower vertical height-depth ratio(  $Sn-Gn'/C-Gn'$ ); 2) vertical height ratio ( $G-Sn / Sn-Me'$ )  
3) vertical lip-chin ratio (  $Sn-Stms/Stmi-Me'$ ) [30].

- Lower facial height ratio:  $Sn-Me'/G-Me'$ .
- Upper facial height ratio:  $G-Sn/G-Me'$ .
- Upper lip height to lower facial height ratio:  $Sn-Stms/Sn-Me'$ .
- Lower lip height to lower facial height ratio:  $Me'-Stmi/Me'-Sn$ .
- Nasal projection to Nasal length ratio:  $G-Pn \leftrightarrow /G-Sn \downarrow$ .
- Nasal projection to upper lip height ratio:  $Sn-Pn \leftrightarrow /Stms-Sn \downarrow$ .

The following mandibular rotation angles were recorded [28-29]:

- FH-GoMe: The relationship between the Frankfort plane and the lower border of the mandible.
- Maxillary-mandibular plane (B) angle: The angle of inclination of the mandible, formed by the mandibular and the palatal planes (ANS-PNS).
- NS-GoMe: The inclination of the mandibular plane relative to the anterior cranial base.

## Statistical analysis

Fifteen cephalograms were randomly selected, retraced, and measurements were obtained after 2 weeks to evaluate the reliability and the reproducibility of landmarks and measurements. Minimal error indicated that the reliability rate of all measurements was fair.

All statistical analyses were performed using a software program (SPSS for Windows version 18). The mean and standard deviation for each variable in the different vertical growth patterns were calculated. Gender dimorphism was explored for each variable using independent samples t-test at  $p < 0.05$  significance level. Analysis of variance and post-hoc analysis test were used to examine difference among the groups at  $p < 0.05$ . Pearson's correlation coefficients between mandibular rotation angles and facial proportions variables were determined for males and females separately. The "r" value was described as significant at  $p < 0.05$  and highly significant at  $p < 0.01$ .

Facial proportions	Forward rotation		Normal rotation		Backward rotation	
	Male	Female	Male	Female	Male	Female
<b>S-Go /N-Me</b>	0.72 ± 0.038	0.72 ± 0.034	0.65 ± 0.029	0.66 ± 0.015	0.64 ± 0.026*	0.60 ± 0.034*
<b>Me-Ans/N-Me</b>	0.57 ± 0.021	0.56 ± 0.017	0.57 ± 0.019	0.57 ± 0.020	0.59 ± 0.023	0.57 ± 0.022
<b>N-Ans /N-Me</b>	0.43 ± 0.021	0.44 ± 0.017	0.43 ± 0.014	0.42 ± 0.018	0.41 ± 0.023	0.43 ± 0.023
<b>S-Ar/S-Go</b>	0.39 ± 0.025	0.38 ± 0.035	0.42 ± 0.032	0.41 ± 0.038	0.43 ± 0.021	0.44 ± 0.056
<b>Ar-Go /S-Go</b>	0.61 ± 0.025	0.62 ± 0.035	0.60 ± 0.053	0.59 ± 0.039	0.57 ± 0.021	0.56 ± 0.056

\* p<0.05.

Table 2: Statistical comparison of the skeletal facial proportions in the different mandibular rotation groups between males and females (mean and standard deviation).

Facial proportions	Forward rotation		Normal rotation		Backward rotation	
	Male	Female	Male	Female	Male	Female
<b>G'-Sn/Sn-Me'</b>	0.96 ± 0.094*	1.03 ± 0.078*	0.93 ± 0.086	0.99 ± 0.064	0.93 ± 0.093*	1.09 ± 0.095*
<b>Sn-Gn'/C-Gn'</b>	1.17 ± 18.17	6.42 ± 3.626	1.72 ± 25.15	10.31 ± 5.392	2.97 ± 22.22	4.08 ± 25.79
<b>Sn-Stms/Stmi-Me'</b>	0.44 ± 0.036	0.45 ± 0.075	0.47 ± 0.040	0.47 ± 0.031	0.46 ± 0.039	0.47 ± 0.049
<b>Sn-Me'/ G'-Me'</b>	0.51 ± 0.014	0.49 ± 0.019	0.52 ± 0.022	0.50 ± 0.016	0.52 ± 0.024*	0.48 ± 0.022*
<b>G'-Sn/G'-Me'</b>	0.49 ± 0.014	0.51 ± 0.019	0.48 ± 0.022	0.50 ± 0.016	0.48 ± 0.024*	0.52 ± 0.021*
<b>Sn-Stms/Sn-Me'</b>	0.31 ± 0.021	0.31 ± 0.027	0.29 ± 0.034*	0.31 ± 0.020*	0.32 ± 0.038	0.30 ± 0.031
<b>Me'-Stmi/Me'-Sn</b>	0.69 ± 0.029	0.66 ± 0.043	0.69 ± 0.033	0.68 ± 0.031	0.69 ± 0.025*	0.66 ± 0.030*
<b>G'-Pn↔/G'-Sn↑</b>	0.36 ± 0.133	0.31 ± 0.071	0.30 ± 0.069	0.30 ± 0.060	0.36 ± 0.049	0.31 ± 0.077
<b>Sn-Pn↔/Stms-Sn↑</b>	0.79 ± 0.114	0.82 ± 0.220	0.68 ± 0.107	0.74 ± 0.096	0.76 ± 0.091	0.89 ± 0.217

\* p<0.05.

Table 3: Statistical comparison of the soft tissue facial proportions in the different mandibular rotation groups between males and females (mean and standard deviation).

## Results

Descriptive statistics and comparison between males and females of the skeletal and soft tissue facial proportions for males and females in the different mandibular rotation groups are presented in tables 2 and 3.

Results for comparing variables among the 3 groups of mandibular rotation are presented in table 4 for skeletal facial proportions and in table 5 for soft tissue facial proportions.

The correlation coefficients of the mandibular rotation angles with skeletal and soft tissue facial proportions for males and females were described in tables 6 and 7.

Only the skeletal proportion of total posterior facial height and total anterior facial height in backward

rotation group showed significant difference between the sexes (p<0.05) where males showed higher value than females.

However, the soft tissue proportion of G-Sn/Sn-Me' showed significant difference between the sexes in forward and backward rotation groups where females showed higher value than males. The soft tissue proportion of Sn-Stms/Sn-Me' showed significant difference between the sexes in normal rotation group where females showed higher value than males. The soft tissue proportions of Sn-Me'/G-Me', G-Sn/G-Me' and Me'-Stmi/Me'-Sn showed significant difference between the sexes in backward rotation group where males showed higher value than females in Sn-Me'/G-Me' and Me'-Stmi/Me'-Sn, and females showed

higher value than males in G-Sn/G-Me' as shown in (Tables 2 and 3).

No statistical differences between the mandibular rotation groups with regard to Me-Ans/N-Me and N-Ans /N-Me (Table 4).

However, the groups were considered different from each other in terms of proportion of TPFH and TAFH (S-Go /N-Me). Forward rotation exhibited significantly higher means, followed by normal rotation and backward rotation, who displayed lower means. Regarding S-Ar/S-Go, there were no significant differences between backward rotation and normal rotation. However, the forward rotation group exhibited significantly lower means compared with the other groups.

Regarding Ar-Go /S-Go, statistical differences were detected in the analy-

Variables	Rotation type	N	Mean	ANOVA test	Post-hoc tests	
						Mean difference
S-Go /N-Me	Forward	22	0.72 ± 0.036	0.0001*	F – N	0.064*
	Normal	20	0.66 ± 0.022		F – B	0.105*
	Backward	20	0.61 ± 0.035		B – N	4.050
Me-Ans/N-Me	Forward	22	0.56 ± 0.020	0.170	F – N	-0.010-
	Normal	20	0.57 ± 0.019		F – B	-0.011-
	Backward	20	0.57 ± 0.024		B – N	0.001
N-Ans /N-Me	Forward	22	0.44 ± 0.020	0.109	F – N	0.012
	Normal	20	0.43 ± 0.016		F – B	0.011
	Backward	20	0.43 ± 0.024		B – N	0.002
S-Ar/S-Go	Forward	22	0.39 ± 0.029	0.0001*	F – N	-0.029-*
	Normal	20	0.42 ± 0.035		F – B	-0.049-*
	Backward	20	0.44 ± 0.045		B – N	0.019
Ar-Go /S-Go	Forward	22	0.61 ± 0.029	0.001*	F – N	0.017
	Normal	20	0.60 ± 0.045		F – B	0.049*
	Backward	20	0.56 ± 0.045		B – N	-0.032-*

\* p<0.05

Table 4: Comparison of variables among the three mandibular rotation groups for skeletal facial proportions.

sis including all groups. In paired analysis, there were no statistically significant differences between forward rotation and normal rotation. However, this difference reach a statistically significant level between forward rotation and backward rotation groups, and between backward rotation and normal rotation groups with the higher means in forward rotation group.

The groups were considered different from each other only in terms of the proportion of the nasal tip projection and the length of the nose (Sn-P↔/Stms-Sn↑) (Table 5). In paired analysis, however, this difference did not reach a statistically significant level although it was more significant when backward rotation and normal rotation groups were confronted with each other. In this comparison, backward rotation had higher means than other rotation groups.

A significant correlation was found between skeletal proportions and man-

dibular rotation angles (NS-GoMe, B, Bjork, FH-GoMe) in males and females.

In males and females, as shown in table 5, S-Go /N-Me was negatively correlated with NS-GoMe, B, Bjork, and FH-GoMe. Me-Ans/N-Me was positively correlated with B angle. Ar-Go/S-Go was negatively correlated with NS-GoMe, B, Bjork and FH-GoMe. S-Ar/S-Go was positively correlated with NS-GoMe, B, Bjork and FH-GoMe.

N-Ans /N-Me was negatively correlated with B angle in males and negatively correlated with NS-GoMe, B and Bjork in females.

Different correlation levels among the variables were detected (Table 7). In males, G-Sn/Sn-Me' and G-Sn/G-Me' were negatively correlated with B and FH-GoMe. Sn-Me'/G-Me' was positively correlated with B and FH-GoMe.

In females, G-Sn/Sn-Me' was positively correlated with NS-GoMe and Bjork. Sn-Me'/G-Me' was negatively correlated with NS-GoMe and Bjork.

Finally, G-Sn/G-Me' was positively correlated with NS-GoMe and Bjork.

## Discussion

Subjects falling within 18–25 years age range were selected since most of the growth would have been completed by that time and the skeletal pattern is established and becomes constant [32]. In addition, Bishara [21] in his longitudinal study concluded that the differences among facial types were more pronounced at adulthood.

Studies have shown that the growth changes of the facial tissues, although not completed, occurred predominantly before the age of 18 years [31, 32].

Differences between skeletal and soft tissue facial proportions for the various mandibular rotations and correlation between facial propor-

Variables	Rotation type	N	Mean	ANOVA test	Post-hoc tests	
						Mean difference
<b>G'-Sn/Sn-Me'</b>	Forward	22	0.99 ± 0.094	0.146	F - N	0.023
	Normal	20	0.96 ± 0.080		F - B	-0.039-
	Backward	20	1.03 ± 0.122		B - N	0.063
<b>Sn-Gn'/C-Gn'</b>	Forward	22	3.32 ± 17.874	0.763	F - N	-1.583-
	Normal	20	4.90 ± 23.901		F - B	2.775
	Backward	20	0.54 ± 18.702		B - N	-4.358-
<b>Sn-Stms/Stmi-Me'</b>	Forward	22	0.44 ± 0.054	0.141	F - N	-0.025-
	Normal	20	0.47 ± 0.034		F - B	-0.023-
	Backward	20	0.47 ± 0.044		B - N	-0.002-
<b>Sn-Me'/G'-Me'</b>	Forward	22	0.50 ± 0.017	0.138	F - N	-0.009-
	Normal	20	0.51 ± 0.021		F - B	0.005
	Backward	20	0.50 ± 0.030		B - N	-0.015-
<b>G'-Sn/ G'-Me'</b>	Forward	22	0.50 ± 0.017	0.122	F - N	0.009
	Normal	20	0.49 ± 0.021		F - B	-0.006-
	Backward	20	0.50 ± 0.030		B - N	0.015*
<b>Sn-Stms/Sn-Me'</b>	Forward	22	0.31 ± 0.023	0.557	F - N	0.007
	Normal	20	0.30 ± 0.029		F - B	-0.003-
	Backward	20	0.31 ± 0.034		B - N	0.010
<b>Me'-Stmi/Me'-Sn</b>	Forward	22	0.68 ± 0.036	0.367	F - N	-0.008-
	Normal	20	0.68 ± 0.031		F - B	0.0001
	Backward	20	0.68 ± 0.031		B - N	-0.008-
<b>G'-Pn↔/G'-Sn↓</b>	Forward	22	0.34 ± 0.112	0.321	F - N	0.039
	Normal	20	0.30 ± 0.063		F - B	0.010
	Backward	20	0.33 ± 0.071		B - N	0.029
<b>Sn-Pn↔/Stms-Sn↓</b>	Forward	22	0.80 ± 0.161	0.039*	F - N	0.087
	Normal	20	0.71 ± 0.103		F - B	-0.039-
	Backward	20	0.84 ± 0.188		B - N	0.125*

\* p<0.05.

Table 5: Comparison of variables among the three mandibular rotation groups for soft tissue facial proportions.



Facial proportions	Male				Female			
	NS-GoMe	B	Bjork	FH-GoMe	NS-GoMe	B	Bjork	FH-GoMe
<b>S-Go /N-Me</b>	0.748-**	0.699-**	0.685-**	0.657-**	0.951-**	0.809-**	0.956-**	0.834-**
<b>Me-Ans/N-Me</b>	0.328	0.550**	0.346	0.3	0.054	0.497**	0.061	0.083
<b>N-Ans /N-Me</b>	0.365-*	0.588-**	0.379-*	0.342-	0.048-	0.493-**	0.055-	0.088-
<b>S-Ar/S-Go</b>	0.489**	0.473**	0.461*	0.579**	0.511**	0.545**	0.531**	0.601**
<b>Ar-Go /S-Go</b>	0.354-	0.370-*	0.466-**	0.448-*	0.506-**	0.531-**	0.529-**	0.612-**

\*  $p < 0.05$ ; \*\*  $p < 0.01$ .

\*: Weak correlation level ( $\pm 0.1 \leq r < \pm 0.5$ );

\*\* : Moderate correlation level ( $\pm 0.5 \leq r < \pm 0.8$ );

\*\*\* : Strong correlation level ( $\pm 0.8 \leq r < \pm 1$ ) [31].

Table 6: Correlation of the mandibular rotation angles with skeletal facial proportions for males and females.

tions and mandibular rotation have rarely been described in the literature.

In our study, a significant difference was observed between males and females for the ratio of TPFH to TAFH with males exhibiting higher values than females in backward rotation group; i.e., a well-developed posterior facial height especially in backward rotation. This is in agreement with Kharbanda study [33] who found a significant difference between males and females for the ratio of TAFH to TPFH in a sample of adult subjects with excellent occlusion and good facial harmony. However, Utomi [34] found that in Hausa-Fulani children, TPFH/TAFH was 61.5% for males and 63% for females.

The findings of the present study showed no significant differences between males and females in the ratio of UAFH to TAFH, LAFH to TAFH, UPPFH to TPFH and LPFH to TPFH in different mandibular rotation groups. This is in agreement with Utomi study [34], in which UAFH/TAFH was 44.2% for males and 44.1% for females. LPFH/TPFH was constant (58.4%) for both sexes.

The rotation groups were considered different from each other in terms of proportion of TPFH and TAFH

(S-Go /N-Me) and LPFH to TPFH (Ar-Go /S-Go). Forward rotation group exhibited significantly higher means, followed by normal rotation and backward rotation groups, who displayed the lower means.

Regarding the soft tissue facial proportions, vertical height ratio (G'-Sn/Sn-Me') was found greater in females, significantly in forward and backward rotation groups indicating tendency of males to have longer lower facial height than females. Similar results were obtained by AlBarakati study [35] who reported that vertical height ratio was greater in adult Saudi females ( $1.02 \pm 0.10$ ) than in males ( $1.00 \pm 0.09$ ) even though the difference was not significant.

Lower vertical height-depth ratio (Sn-Gn' /C-Gn') was also greater in females than males but the difference wasn't significant; this might be reflected by the prevalence of shorter neck among females.

Upper facial height ratio (G-Sn/G-Me') is also significantly greater in females in backward rotation group, indicating increased anterior facial height in males than females. This is in agreement with the results of Sayagh et al. [36] who found that males

showed significantly longer upper and lower facial height than females in all facial types.

Lower lip height to lower facial height ratio (Me'-Stmi/Me'-Sn) was greater in males than females significantly in backward rotation, indicating increased lower lip height (Me'-Stmi) in males than females. These findings were in agreement with those of Sayagh et al., [36] who reported that males showed significantly longer chin height than females.

Also, we found that nasal projection to nasal length ratio (G-Pn↔/G-Sn↓) was greater in males than females in all rotation groups but the difference wasn't significant. The same result was obtained by Nahidh [37] and other studies [38-41] who reported that males showed more prominent and longer nose than females in adult class I subjects.

The proportion of nasal projection to upper lip height (Sn-Pn↔/Stms-Sn↓) was different in the three rotation groups. Backward rotation exhibited significantly higher means than forward rotation. These results indicated that the nasal projection tend to increase with the backward rotation. Nahidh [37] found that the

Facial proportions	Males				Females			
	NS-GoMe	B	Bjork	FH-GoMe	NS-GoMe	B	Bjork	FH-GoMe
<b>G'-Sn/Sn-Me'</b>	0.215-	0.359-	0.228-	0.363-*	0.368*	0.051	0.377*	0.301
<b>Sn-Gn'/C-Gn'</b>	0.100-	0.051	0.074-	0.078-	0.326-	0.388-*	0.334-	0.357-*
<b>Sn-Stms/Stmi-Me'</b>	0.334	0.269	0.323	0.298	0.002-	0.032	0.011	0.017
<b>Sn-Me'/G'-Me'</b>	0.331	0.551**	0.345	0.415*	0.355-*	0.043-	0.362-*	0.296-
<b>G'-Sn/ G'-Me'</b>	0.331-	0.551-**	0.345-	0.415-*	0.366*	0.061	0.375*	0.302
<b>Sn-Stms/Sn-Me'</b>	0.072	0.01	0.126	0.099	0.072-	0.114-	0.087-	0.163-
<b>Me'-Stmi/Me'-Sn</b>	0.088	0.006	0.053	0.06	0.105-	0.05	0.056-	0.066
<b>G'-Pn↔/G'-Sn↑</b>	0.215-	0.359-	0.228-	0.363-*	0.368*	0.051	0.377*	0.301
<b>Sn-Pn↔/Stms-Sn↑</b>	0.055-	0.124-	0.020-	0.112-	0.108-	0.024-	0.076-	0.128-

\*  $p < 0.05$ ; \*\*  $p < 0.01$ .

\*: Weak correlation level ( $\pm 0.1 \leq r < \pm 0.5$ );

\*\* : Moderate correlation level ( $\pm 0.5 \leq r < \pm 0.8$ );

\*\*\*: Strong correlation level ( $\pm 0.8 \leq r < \pm 1$ ) [30].

Table 7: Correlation of the mandibular rotation angles with soft tissue facial proportions for males and females.

nasal length and projection tend to increase with the increments of the facial heights which increase with mandibular rotation.

In males, a significant positive correlation was found between lower facial height ratio (Sn-Me'/G-Me') and (B and Bjork), and a significant negative correlation between upper facial height ratio (G-Sn/G-Me') and (B and Bjork); any increase in these rotation angles was associated with an increase in Sn-Me'.

While in females, the correlation was significantly negative between lower facial height ratio (Sn-Me'/G-Me') and (NS-GoMe and FH-GoMe), and significantly positive between upper facial height ratio (G-Sn/G-Me') and (NS-GoMe and FH-GoMe); the increase in these rotation angles was associated with an increase in G-Me'.

These findings reflect dimorphism between sexes.

## Conclusion

Within the limitations of the present study, we can conclude that:

-The soft tissue profile tended to follow the contour of the underlying skeletal profile, although in some cases this was not the case, probably due to variations in the soft tissue thickness.

-Sexual dimorphism was detected especially in soft tissue facial proportions.

-Skeletal facial proportions were more correlated with mandibular rotation than soft tissue facial proportions.

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