Original Article

Assessment of the soft tissue thickness at the lower anterior face in adult patients with different skeletal vertical patterns using cone-beam computed tomography

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ABSTRACT

Objective: To evaluate and compare the soft tissue thickness values at the lower anterior face among adult patients with different vertical growth patterns using cone-beam computed tomography.

Material and Methods: The study sample consisted of 105 adult patients (54 women and 51 men) with a normal sagittal skeletal pattern divided into three groups according to the vertical growth pattern: high-angle (women/men, 22/13; mean age, 24.54 ± 4.45 years), low-angle (women/men, 14/21; mean age, 24.62 ± 5.08 years), and normal-angle (women/men, 18/17; mean age, 24.22 ± 5.40 years) groups. The soft tissue thickness measurements at the lower anterior face in each group were done and analyzed using the one-way analysis of variance and Tukey tests.

Results: Soft tissue thickness values were the lowest in the high-angle group for both women and men. For women, the thickness values at the labrale superius, labrale inferius, and pogonion were found to be statistically significantly smaller in the high-angle group (11.49 ± 1.05 mm, 12.70 ± 1.92 mm, and 11.64 ± 2.65 mm, respectively) compared with the values in the normal-angle group (13.31 ± 2.01 mm, 15.08 ± 1.94 mm, and 14.69 ± 3.08 mm, respectively) ($P < .05$, $P < .05$, and $P < .01$, respectively). For men, however, no statistically significant differences were found among the vertical growth patterns ($P > .05$).

Conclusion: Women had statistically significantly thinner thickness at the labrale superius, labrale inferius, and pogonion in the high-angle group compared with the normal-angle group. (*Angle Orthod.* 2015;85:211–217.)

KEY WORDS: Vertical pattern; Soft tissue thickness; Cone-beam computed tomography

INTRODUCTION

Facial vertical growth patterns, including high angle (hyperdivergent), low angle (hypodivergent), and normal angle (normodivergent), might develop during the growth period due to several factors. These include the growth of the jaws, dentoalveolar development, eruption of the teeth, and function of the tongue and lips.[1] If vertical growth at the condyles is less than vertical growth at the facial sutures and/or alveolar processes, the mandible rotates backward. Conversely, if vertical growth at the condyles exceeds the sum of the vertical growth components at the facial sutures and alveolar processes, the mandible rotates forward.[2]

A hyperdivergent growth pattern is typically associated with a decreased posterior to anterior facial height ratio, an increased lower facial height, a steep mandibular plane, and an anterior open bite,[3] while a hypodivergent growth pattern exhibits opposite features to the hyperdivergent growth pattern.[4]

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Evaluation of the soft tissues in patients undergoing orthodontic treatment or orthognathic surgery plays a crucial role in diagnosis and treatment planning.[5] The ratio of the soft tissue transition to the hard tissue change is generally calculated when visualized treatment objectives are assessed in planning orthognathic surgery. However, precise analysis of the soft tissue characteristics is needed to predict surgical outcomes.[6] A recent study[7] showed different soft tissue thickness changes after bimaxillary surgery in patients with thick and thin soft tissues.

Several attempts have been made to analyze facial soft tissue thickness in different populations representing sagittal skeletal malocclusions.[5,8] Those studies reported statistically significant differences for thickness of the upper and lower lips, stomion, subnasale, and gnathion among patients with skeletal Class I, II, and III malocclusion. However, it has been almost neglected for patients with different vertical growth patterns. A bibliographic search in Medline using PubMed and the key words ''soft tissue,'' ''soft tissue thickness,'' ''facial profile,'' and ''vertical growth pattern'' showed that there has been only one study[9] investigating the association between soft tissue chin thickness and different vertical growth patterns. Within the limitations of that study,[9] which was performed on cephalometric lateral films, the soft tissue thickness values were thinner in the high-angle group than in the other groups.

The aim of the present study was to evaluate and compare the soft tissue thickness values at the lower anterior face among the adult patients with different vertical growth patterns using cone-beam computed tomography (CBCT).

MATERIAL AND METHODS

The images used in the present study were part of the diagnostic records collected due to dental treatment need. No patients were contacted and no CBCTs were taken for the objective of the present study. The patients had signed an informed consent form allowing the use of their data for scientific purposes, and the study was approved by the local ethics committee of Erciyes University.

Study sample calculation was based on a formula,[10] a significance level of .05, and a power of 80% to detect a difference of 2.1 mm ($\pm$2.3 mm) for the gnathion thickness between the high-angle and low-angle groups using the findings of Macari and Hanna.[9] The power analysis showed that 19 patients were needed in each group. To increase the power of the study, more patients were included in each group.

The study sample, randomly selected from the archive of the Erciyes University, comprised a total of 105 patients (54 women and 51 men) aged 18–30 years divided into high-angle, low-angle, and normal-angle groups based on vertical growth pattern using the SN-MP angle (high-angle group $\geq 38^{\circ}$; low-angle group $\leq 26^{\circ}$; and control group or normal angle group $26–38^{\circ}$).[11,12] The sample included 35 patients in each group: high-angle group (22 women and 13 men; mean age, 24.54 $\pm$ 4.45 years), low-angle group (14 women and 21 men; mean age, 24.62 $\pm$ 5.08 years), and normal-angle group (18 women and 17 men; mean age, 24.22 $\pm$ 5.40 years). All patients had skeletal Class I ($1 < \text{ANB} < 5$)[5,13] relationships and the same ethnic origin. None of the patients had a trauma history; craniofacial anomaly; previous orthodontic, prosthodontic, and orthognathic surgery treatments, and a body mass index >28.

The images were obtained in a standard supine position (scanning time, 14–18 seconds; collimation height, 13 cm; exposure time. 3.6 seconds; segmentation level, 0.25 mm; and voxel size, 0.3 mm^3) using the same device (NewTom 5G, QR, Verona, Italy). Patients were asked to bite with maximum intercuspation with relaxed lip position and not to move their head or tongue during scanning. The images were transformed to digital imaging and communications in medicine (DICOM) and then the Simplant Pro software, version 13.0 (Materialise, Leuven, Belgium) was used to perform the soft tissue thickness measurements at the lower anterior face (subnasale, labrale superius, stomion, labrale inferius, labiomentale, pogonion, and gnathion)[5,8] and angular measurements (ANB and SN-GoGn) on the cephalometric lateral radiographs obtained from CBCT (Figure 1). All thickness measurements were blindly and randomly made by an experienced maxillofacial radiologist (AES) who had no knowledge of the patient's vertical growth pattern. Cephalometric angular measurements were done by an experienced orthodontist (SKB).

Statistical Analysis

To determine the random error, 40 images were selected randomly and then all linear measurements were repeated 3 weeks after the first examination by the same maxillofacial radiologist with no knowledge of the first measurements. Intraclass correlation coefficients (ICC) were performed to assess the reliability of the measurements, and the difference between the two examinations was tested by means of a paired *t*-test.

After performing the normality test of Shapiro-Wilks, all data were found to be normally distributed; thus, parametric tests were used for further comparisons. A Pearson χ^2 test was performed to test gender distribution. A Student *t*-test was performed to examine gender differences in each group. One-way

Figure 1. Linear measurements (in millimeters) used in the study. (A) Subnasale (the distance of A-Sn). (B) Labrale superius (prosthion-Ls). (C) Stomion (the shortest distance from upper incisor to Sto). (D) Labrale inferius (infradentale-Li). (E) Labiomentale (B-Labm). (F) Pogonion (Pog-Pog'). (G) Gnathion (Gn-Gn'). Angular measurements (in degrees) used in the study were SN-MP and ANB.

analysis of variance (ANOVA) and post-hoc test (Tukey honestly significant difference) were used for multiple comparisons (chronological age and angular and linear measurements). All statistical analyses were performed using the SPSS software package program (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, IL). A P value $< .05$ was considered statistically significant.

RESULTS

The ICC values were $>.993$, confirming the reliability of the measurements. In addition, results of the paired *t*-test showed that the measurements were free of the systemic error ($P > .05$).

Table 1 shows the demographic data of the patients included to the groups. The groups were statistically well matched on gender distribution, chronological ages, and sagittal relationships ($P > .05$). Statistically significant differences were present among the groups for the SN-MP angle (high-angle group, 41.41 ± 3.64°; low-angle group, 23.28 ± 2.79°; and normal-angle group, 32.19 ± 3.09°) at a significance level of $P < .001$.

Table 2 shows the soft tissue thickness at the lower anterior face between genders in each vertical growth pattern. The thickness values for men were higher in all vertical growth patterns compared with the values for the women. Because statistically no significant differences were found only for the thicknesses at the

Table 1. Comparison of the Demographic Variables Among Different Vertical Patterns [a]

	N	Women/Men	Mean Age (Years)	ANB (°)	SN-MP (°)
High-angle group	35	22/13	24.54 ± 4.45	3.65 ± 1.53	41.41 ± 3.64[x]
Low-angle group	35	14/21	24.62 ± 5.08	3.03 ± 1.54	23.28 ± 2.79[y]
Normal-angle group	35	18/17	24.22 ± 5.40	3.49 ± 1.20	31.89 ± 3.16[z]
Total	105	54/51	24.46 ± 4.95	3.39 ± 1.44	32.19 ± 3.09
P	NS	NS	NS	NS	**.000**

[a] Results of one-way analysis of variance: [x,y,z] Statistically significant differences among groups at $P < .001$.

Table 2. Comparison of the Soft Tissue Thickness at the Lower Anterior Face Between Genders in Each Vertical Growth Pattern[a]

	Group	Gender	N	Mean (mm)	SD	SE	*P*[b]
Subnasale	High angle	Women	22	14.29	2.55	0.54	**.029**
		Men	13	16.69	3.63	1.01	
	Low angle	Women	14	15.41	2.77	0.74	**.004**
		Men	21	18.37	2.72	0.59	
	Normal angle	Women	18	16.28	3.13	0.74	NS
		Men	17	17.25	2.39	0.58	
Labrale superius	high angle	Women	22	11.49	1.05	0.22	**.018**
		Men	13	13.07	2.01	0.56	
	Low angle	Women	14	11.89	2.76	0.74	**.004**
		Men	21	14.86	2.63	0.57	
	Normal angle	Women	18	13.31	2.01	0.47	**.035**
		Men	17	14.71	1.75	0.42	
Stomion	High angle	Women	22	7.15	1.33	0.28	**.000**
		Men	13	9.34	1.62	0.45	
	Low angle	Women	14	7.95	2.06	0.55	**.002**
		Men	21	10.40	2.06	0.45	
	Normal angle	Women	18	8.39	2.19	0.52	**.042**
		Men	17	9.85	1.87	0.45	
Labrale inferius	High angle	Women	22	13.60	1.92	0.41	**.003**
		Men	13	15.81	2.14	0.59	
	Low angle	Women	14	12.70	3.05	0.81	**.000**
		Men	21	16.27	1.79	0.39	
	Normal angle	Women	18	15.08	1.94	0.46	**.000**
		Men	17	16.72	1.69	0.41	
Labiomentale	High angle	Women	22	12.07	2.07	0.44	NS
		Men	13	12.85	1.86	0.52	
	Low angle	Women	14	12.14	1.45	0.39	NS
		Men	21	12.94	1.19	0.26	
	Normal angle	Women	18	12.27	1.86	0.44	NS
		Men	17	13.29	1.61	0.39	
Pogonion	High angle	Women	22	11.64	2.65	0.56	NS
		Men	13	13.30	3.23	0.90	
	Low angle	Women	14	12.54	2.29	0.61	NS
		Men	21	13.87	2.36	0.52	
	Normal angle	Women	18	14.45	3.08	0.73	NS
		Men	17	14.69	2.20	0.53	
Gnathion	High angle	Women	22	5.61	1.42	0.30	**.006**
		Men	13	7.23	1.84	0.51	
	Low angle	Women	14	7.02	2.17	0.58	NS
		Men	21	8.15	2.20	0.48	
	Normal angle	Women	18	6.75	2.56	0.60	NS
		Men	17	8.13	2.51	0.61	

[a] SD indicates standard; SE, standard error; NS, not significant.
[b] Results of Student *t*-test comparing genders.
Statistically significant values are shown in boldface type.

labiomentale and pogonion, women and men were separately examined for further comparisons.

The comparison of soft tissue thickness at the lower anterior face for women and men are shown in Tables 3 and 4, respectively. Soft tissue thickness values were the lowest in the high-angle group for both women and men. For women, the thickness values at the labrale superius, labrale inferius, and pogonion were found to be statistically significantly smaller in the high-angle group (11.49 $\pm$ 1.05 mm, 12.70 $\pm$ 1.92 mm, and 11.64 $\pm$ 2.65 mm, respectively) compared with the values in the normal-angle group (13.31 $\pm$ 2.01 mm, 15.08 $\pm$ 1.94 mm, and 14.69 $\pm$ 3.08 mm, respectively) ($P < .05$, $P < .05$, and $P < .01$, respectively). In addition, the low-angle and normal-angle groups showed similar thickness values ($P > .05$). For men, however, no statistically significant differences were found among the vertical growth patterns.

DISCUSSION

In the present study, we aimed to assess the soft tissue thickness at the lower anterior face in adult patients with different vertical growth patterns and to compare the values between women and men and among the vertical groups using CBCT images

Table 3. Comparison of the Soft Tissue Thickness Values at the Lower Anterior Face for Women with Different Vertical Patterns[a]

							Tukey HSD		
	Group	N	Mean	SD	SE	*P*	I-II	I-III	II-III
Subnasale	High angle	22	14.29	2.55	0.54	NS	NS	NS	NS
	Low angle	14	15.41	2.77	0.74				
	Normal angle	18	16.28	3.13	0.74				
	Total	54	15.24	2.89	0.39				
Labrale superius	High angle	22	11.49	1.05	0.22	**.014**	NS	**0.013**	NS
	Low angle	14	11.89	2.76	0.74				
	Normal angle	18	13.31	2.01	0.47				
	Total	54	12.20	2.06	0.28				
Stomion	High angle	22	7.15	1.33	0.28	NS	NS	NS	NS
	Low angle	14	7.95	2.06	0.55				
	Normal angle	18	8.39	2.19	0.52				
	Total	54	7.77	1.89	0.26				
Labrale inferius	High angle	22	12.70	1.92	0.41	**0.015**	NS	**0.013**	NS
	Low angle	14	13.60	3.05	0.81				
	Normal angle	18	15.08	1.94	0.46				
	Total	54	13.86	2.42	0.33				
Labiomentale	High angle	22	12.07	2.07	0.44	NS	NS	NS	NS
	Low angle	14	12.14	1.45	0.39				
	Normal angle	18	12.27	1.86	0.44				
	Total	54	13.03	1.51	0.21				
Pogonion	High angle	22	11.64	2.65	0.56	**.003**	NS	**0.003**	NS
	Low angle	14	12.54	2.29	0.61				
	Normal angle	18	14.69	3.08	0.73				
	Total	54	12.89	2.98	0.41				
Gnathion	High angle	22	5.61	1.42	0.30	NS	NS	NS	NS
	Low angle	14	7.02	2.17	0.58				
	Normal angle	18	6.75	2.56	0.60				
	Total	54	6.36	2.11	0.29				

[a] SD indicates standard deviation; SE, standard error; HSD, honestly significant difference; NS, not significant; I, high-angle group, II, low-angle group, III, normal-angle group.

Statistically significant values are shown in boldface type.

retrospectively; this assessment has not been previously reported in the literature. The vertical groups included in the study were statistically well matched on gender distribution, chronological ages, and sagittal relationships. Because statistically significantly greater values were found for soft tissue thickness measurements in men than in women, further comparisons were done separately for women and men to eliminate the effect of gender on findings. Several studies[6,14–17] evaluating soft tissue cephalometric norms for different populations with different chronological ages reported that facial soft tissue thickness values were greater in men than in women. This difference was also noted for subjects with different skeletal malocclusions.[5,18,19] In general, women's skin lacks collagen synthesis and facilitates synthesis of hyaluronic acid because of estrogen. In contrast, men tend to have thicker skin because testosterone facilitates collagen synthesis.[6]

In the literature, only one study[9] using conventional lateral cephalometric radiographs investigated soft tissue chin thickness in adult patients with various mandibular divergence patterns. However, lateral cephalometric films were shown to have severe limitations, including distortion, low reproducibility, differences in magnification, and the superimposition of bilateral craniofacial structures compared with the CBCT.[12,20–23] In addition, CBCT technology made it feasible to achieve true (1:1 size) images without magnification and showed high intraobserver and interobserver reproducibility.[24] In the present study, ICC values for all variables were $>.993$, confirming the reported[21–23,25] high reliability of the CBCT technique.

According to Macari and Hanna,[9] the thickness values at the gnathion and menton were thinner in the high-angle group when both genders were combined. However, the difference for gnathion was statistically significant for both women and men when examined separately. In the present study, we found that soft tissue thickness values were the thinnest in the high-angle group for both women and men. However, statistically significant differences were found at the labrale superius ($P < .05$), inferius ($P < .05$), and pogonion ($P < .01$) for women, whereas the differences among the vertical groups were not significant for the men ($P > .05$). In addition, women in the low-angle and normal-angle groups showed similar thickness values ($P > .05$). The disagreement between our findings and those of Macari and Hanna[9] might be due

Table 4. Comparison of the Soft Tissue Thickness Values at the Lower Anterior Face for Men with Different Vertical Patterns[a]

							Tukey HSD		
	Group	N	Mean	SD	SE	P^b	I-II	I-III	II-III
Subnasale	High angle	13	16.69	3.63	1.01	NS	NS	NS	NS
	Low angle	21	18.37	2.72	0.59				
	Normal angle	17	17.25	2.39	0.58				
	Total	51	17.57	2.91	0.41				
Labrale superius	High angle	13	13.07	2.01	0.56	NS	NS	NS	NS
	Low angle	21	14.86	2.63	0.57				
	Normal angle	17	14.71	1.75	0.42				
	Total	51	14.36	2.30	0.32				
Stomion	High angle	13	9.34	1.62	0.45	NS	NS	NS	NS
	Low angle	21	10.40	2.06	0.45				
	Normal angle	17	9.85	1.87	0.45				
	Total	51	9.95	1.90	0.27				
Labrale inferius	High angle	13	15.81	2.14	0.59	NS	NS	NS	NS
	Low angle	21	16.27	1.79	0.39				
	Normal angle	17	16.72	1.69	0.41				
	Total	51	16.30	1.85	0.26				
Labiomentale	High angle	13	12.85	1.86	0.52	NS	NS	NS	NS
	Low angle	21	12.94	1.19	0.26				
	Normal angle	17	13.29	1.61	0.39				
	Total	51	12.15	1.82	0.25				
Pogonion	High angle	13	13.30	3.23	0.90	NS	NS	NS	NS
	Low angle	21	13.87	2.36	0.52				
	Normal angle	17	14.45	2.20	0.53				
	Total	51	13.92	2.55	0.36				
Gnathion	High angle	13	7.23	1.84	0.51	NS	NS	NS	NS
	Low angle	21	8.15	2.20	0.48				
	Normal angle	17	8.13	2.51	0.61				
	Total	51	7.91	2.22	0.31				

[a] SD indicates standard deviation; SE, standard error; HSD, honestly significant difference; NS, not significant; I, high-angle group, II, low-angle group, III, normal-angle group.

[b] Results of one-way analysis of variance.

to racial differences. A review of the literature confirms differences in soft tissue thickness among different ethnic and racial groups. Another reason might be that the authors used conventional cephalometric films for their study, while we used CBCT images retrospectively for the present study. It should be noted that gender distribution, chronological ages, and sagittal relationships of the patients, which might affect the findings, were similar in both studies. Growth differences between men and women on measured hard and soft tissue landmarks might also have affected those gender differences.

It is difficult to compare our findings of upper and lower lip thickness differences among the vertical groups because no previous study has evaluated these parameters. The presence of lip incompetency reported to be found mainly in the hyperdivergent facial pattern[9] might have affected the findings as a muscular strain upon lip closure, although the relaxed lip position was present during scanning. The differences found for upper (mean difference ~2 mm) and lower lip (mean difference ~2.5 mm) between women in the high-angle and normal-angle groups seem to be important for patients who need orthodontic treatment and/or orthognathic surgery. According to Mobarak et al.,[26] preoperative thickness of both upper and lower lip was significantly correlated with the net change in thickness in the sense that the greater the preoperative thickness the greater the expected change. The reported differences after orthognathic surgery in the soft tissue responses between the patients with thick and thin soft tissues should be taken into account while planning the surgery.[7,27] Jakobsone et al.[27] reported different correlation coefficients between soft and hard tissue landmarks and suggested that these differences may be due to different characteristics of the soft tissue, including thickness, volume, and change in the lower face height with the surgery. In light of this information, the present study suggests that the soft tissue thickness at the upper and lower lips and pogonion in women with a high angle should be carefully examined before orthognathic surgery.

CONCLUSIONS

- Soft tissue thickness values were greater in men than in women in all groups.

- The null hypothesis was rejected. Women had statistically significantly thinner thickness at the labrale superius, labrale inferius, and pogonion in the high-angle group compared with the normal-angle group, whereas men had similar soft tissue thickness values at the lower anterior face in all groups.

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