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Assessment of Facial Soft Tissue Dimensions in Adult Patients with Different Sagittal Skeletal Classes using Cone beam Computed Tomography

[1]Heba M Jazmati, [2]Mowaffak A Ajaj, [3]Mohammad Y Hajeer

ABSTRACT

Introduction: Few studies utilized cone beam computed tomography (CBCT) to evaluate soft tissue dimensions in malocclusion patients. The aim of this study was to analyze the three-dimensional (3D) soft tissue relationships of adult patients according to their gender and skeletal sagittal class using CBCT.

Materials and methods: The study sample consisted of 96 CBCT images of patients of both genders; aged 18 to 25 years with a normal vertical skeletal pattern. Patients were segregated into three groups according to their skeletal sagittal class: Class I (2 < ANB < 4), class II (ANB > 4), and class III (ANB < 2). The soft tissue measurements were analyzed in both the sagittal views and frontal volumetric rendered views using 3D-OnDemand software.

Results: In males, the measurements (U1-stom, nasal width, mouth width) were greater in class I than in class II group. Lower lip thickness was greater in class I than in class III group ($p < 0.05$). In females, both labiomental fold thickness and upper lip height measurements showed greater mean values in class II than in class I group. In contrast, lower lip height was greater in class I than in class III group. Ls-Pr, U1-stom, and face width at Cheilion revealed greater values in class III patients than in class II patients. On the other hand, the lower lip thickness, upper lip height, and lower lip height measurements showed greater values in class II than in class III group ($p < 0.05$). Soft tissue thicknesses and measurements were greater in males than in females. However, statistically significant differences between the two sexes were not detected for all of the variables measured in each skeletal class.

Conclusion: The current study indicates the presence of differences in soft tissue thicknesses and facial soft tissue dimensions among skeletal classes and between the two sexes.

Clinical significance: Cone beam computed tomography imaging is a very valuable tool to analyze 3D soft tissue characteristics of patients with different skeletal patterns of malocclusion.

Keywords: Cone beam computed tomography, Sagittal skeletal class of malocclusion, Soft tissue thickness.

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[1-3]Department of Orthodontics, Faculty of Dentistry, Damascus University, Damascus, Syrian Arab Republic

Corresponding Author: Mohammad Y Hajeer, Associate Professor, Department of Orthodontics, Faculty of Dentistry Damascus University, Damascus, Syrian Arab Republic, Phone: +963113141343, e-mail: myhajeer@gmail.com

INTRODUCTION

Facial esthetic considerations are essential in orthodontic treatment planning. One of the goals of orthodontic treatment is to maintain or improve facial balance and esthetics.[1] Thus, it is crucial for orthodontists to understand the full influence that treatment would have on their patients' facial esthetics.

Evaluation of the soft tissues in patients undergoing orthodontic treatment or orthognathic surgery plays an important role in the diagnosis and treatment planning.[2] The ratio of the soft tissue displacement to the hard tissue change is generally calculated when the visualized treatment objectives are assessed in planning orthognathic surgery. However, accurate analysis of the soft tissue characteristics is needed to predict surgical results.[3] A recent study by Abeltins and Jakobsone[4] found different soft tissue responses following bimaxillary surgery in patients with thick and thin soft tissues.

The overlying facial soft tissues can develop in proportion or disproportion to the corresponding bony structures.[5] Variations in length, thickness, and tonicity of the soft tissues may affect the relationships among the facial structures and their positions, thereby affecting facial esthetics.[6] The difficulty to precisely predict soft

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tissue response following any bony movement would make treatment planning for orthognathic surgery incomplete. In addition, cosmetic surgery outcomes would not be easily predicted. In the orthodontic literature, minimal attention has been devoted to the role of soft tissue characteristics in constructing optimal diagnosis and treatment planning. The majority of studies of facial soft tissues evaluated changes after orthodontic treatment[7,8] or orthognathic surgery.[9] The requirement for orthognathic surgery in combination with orthodontic treatment in adult patients has provided important data regarding the relation between soft and hard tissues.[10]

Three-dimensional (3D) imaging can provide a much greater amount of information than those found with two-dimensional (2D) imaging.[11] With the advent of cone beam computed tomography (CBCT) imaging, high-resolution 3D information has become available, representing hard and soft tissues with the added advantage of being less expensive with less irradiation to patients than traditional tomography.[12,13]

No previous study appears to have been undertaken to evaluate facial soft tissue thicknesses and spatial dimensions in patients with different skeletal sagittal classes using CBCT data. Therefore, this study was designed to assess the soft tissue thicknesses and characteristics of orthodontic patients with different skeletal sagittal malocclusions; data that may be useful in diagnosis and surgical-treatment planning.

MATERIALS AND METHODS

This retrospective study was conducted using the records of the patients who were referred to the Department of Orthodontics, Faculty of Dentistry, Damascus University, Damascus, Syrian Arab Republic. All patients had no previous orthodontic, orthognathic, or prosthodontic treatment, and no craniofacial deformities or trauma. All patients were of the same ethnic origin and they had a normal vertical pattern. Before commencing this study, signed consent forms to use their CBCT images were obtained from all patients.

Study sample calculation depended on the following assumptions: A significance level of 0.05 and a power of 80% to detect a difference of 1 mm in upper lip length between two groups, and the variance of this variable was obtained from a previous study.[14] The study sample comprised 96 patients (48 males and 48 females), aged 18 to 25, segregated into three groups, class I, II, and III groups, on the skeletal sagittal relationships using the ANB angle (i.e., class I group: 2 < ANB < 4; class II group: ANB > 4; class III group: ANB < 2).[15] The sample included 32 patients in each group. Each group contained equal numbers of males and females. This distribution was obtained from applying disproportionate multistratified random sampling from a sampling frame of 540 CBCT images collected in the past 5 years (i.e., 2011–2016).

The CBCT images were taken using the same device and in a natural head position. The images were opened in the OnDemand3D program™ (Cypermed Inc., Seoul, Korea). After orienting the images, six measurements were made on the CBCT-derived lateral view of the skull (Fig. 1), and eight measurements were made on the frontal view of the 3D volumetric rendered model of the face (Fig. 2). Soft tissue and hard-tissue landmarks were identified on screen according to the definitions

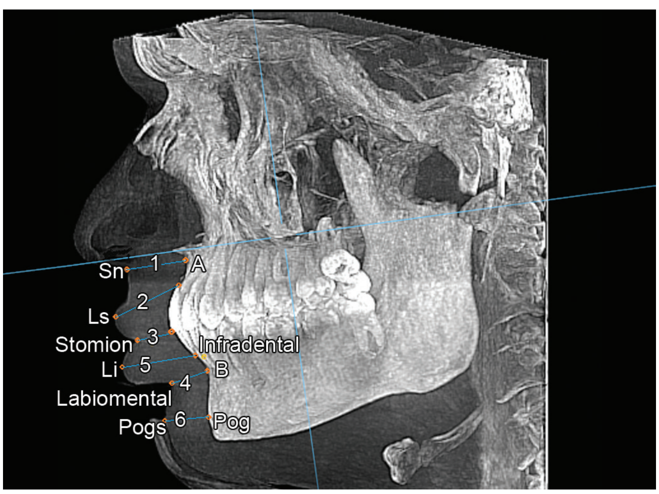

Fig. 1: Lateral view. A cephalometric radiograph extracted from a CBCT image for one of the patients in this study. 1, the distance between point A and subnasale; 2, the distance between Labrale superius and Prosthion; 3, the shortest distance between the upper incisor and Stomion; 4, the distance between Labiomentale and point B; 5, the distance between Labrrale inferius and Infradentale; 6, the distance between Pogonion and soft tissue pogonion

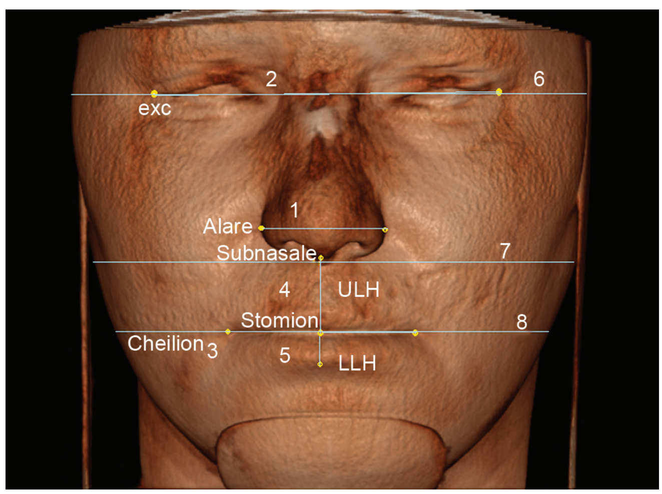

Fig. 2: Frontal view of a 3D volumetric rendered model for one of the patients in this study. 1, nasal width Alare (R)-Alare (L); 2, mouth width Cheilion (R)-Cheilion (L); 3, intercanthal width (excR-excL); 4, upper lip length (Sn-Sts); 5, lower lip length (Sti-ils); 6, facial width at Excanthion; 7, facial width at Subnasale; 8, facial width at Cheilion

Table 1: Landmarks' definitions according to Hajeer et al,[16] Ajaj[17] and Farkas[18]

Alar curvature (or alar crest) (ac)	The most lateral point in the curved base line of each ala, indicating the facial insertion of the nasal wingbase.
Cheilion (ch)	The point located at each labial commissure.
Exocanthion (exc)	The point at the outer commissure of the eye fissure and is located slightly medial to the bony excanthion.
Inferior Labial Sulcus (ILS)	The deepest midline point on the labiomental fold, which determines the lower border of the lower lip.
Labiale inferius (li)	The midpoint of the lower vermilion line.
Labiale superius (ls)	The midpoint of the upper vermilion line.
Stomion inferius (stmi)	The most superior midpoint of the vermilion border of the lower lip.
Stomion superius (stms)	The most inferior midpoint of the vermilion border of the upper lip when the lips at rest. If the lips are closed, this point will fall over Stomion inferius (stmi).
Subnasale (sn)	The midpoint of the angle at the columella base where the lower border of the nasal septum and surface of the upper lip meet. This point is not identical to the bony point ANS or "nasospinale".
Infradentale (Id)	The intersection of the alveolar crest and the outline of the most prominent mandibular incisor.
B	The most posterior point in the outer contour of the mandibular process in the midsagittal plane.
Pogonion (hard tissue)	The most anterior point of the bony chin.
Labiomentale (Lm)	Median point in the transverse groove in the chin at the point where the lower lip is attached, the sulcus labiomentalis.
Subnasale (sn)	The junction point between the columella and the upper cutaneous lip.
Labrale superius (Ls)	The most anterior point on the convexity of the upper lip.
Stomion superius (stms)	The most inferior point of the anterior portion of the upper lip when the lips are apart, or the point of the upper lip at which it merges with the lower lip when the lips are in contact.
Stomion inferius (stmi)	The point of the lower lip at which it merges with the upper lip when the lips are in contact.
Labrale inferius (li)	The most anterior point on the convexity of the lower lip.
Inferior Labial Sulcus (ILS)	The most posterior point on the concavity between the lower lip and the chin, or the deepest point on the labiomental groove.
Pogonion soft tissue (Pogs)	The most anterior point on the convexity of the soft tissue chin.
Nasion (N)	The most anterior point of the nasofrontal suture in the midsagittal plane.
A	The deepest midline point in the curved bony outline of the maxillary alveolar process.
Prosthion (Pr)	The most inferior anterior point of the maxillary alveolar process between the upper central incisors in the midsagittal plane OR.
	The intersection of the alveolar crest and the outline of the most prominent maxillary incisor.

given by Hajeer and Ajaj (Table 1),[9,16,17] and many of the definitions of soft tissue landmarks were based on the anthropometric work of Farkas.[18] Only landmarks that have been proven to be highly reproducible on the 3D volumetric rendered models were used.[16]

On the CBCT-derived lateral view, the following anterior–posterior linear measurements were made (Fig. 1): (1) The distance between point A and subnasale (Sn-A); (2) the distance between Labrale superius and Prosthion (Ls-Pr); (3) the shortest distance between the upper incisor and Stomion (U1-stom); (4) labiomental fold thickness, the distance between Labiomentale and point B (B-Lm); (5) lower lip thickness, the distance between Labrrale inferius and Infradentale (Li-Id); (6) chin thickness, the distance between Pogonion and soft tissue pogonion (Pog-pogs).

On the frontal view of the 3D volumetric rendered model, the following linear measurements were made (Fig. 2): (1) nasal width Alare (R)-Alare (L); (2) mouth width Cheilion (R)-Cheilion (L); (3) intercanthal width Exocanthion (R)-Exocanthion (L); (4) upper lip length ULH (Subnasale-Stomion superius); (5) lower lip length LLH (Stomion inferius-inferior labial sulcus); (6) facial width at the level of Exocanthion; (7) facial width at the level of Subnasale; (8) facial width at the level of Cheilion.

The measuring procedure during the use of 3D-OnDemand was blinded to the assessor. All assessments were performed by the first author (HMJ). To determine the intraobserver reliability, all measurements were repeated after 1 month on 10 randomly selected CBCT radiographs (nearby 10% of the sample). Systematic error was detected using paired t tests, whereas the random error was assessed using interclass correlation coefficients (ICCs).

STATISTICAL ANALYSIS

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (Chicago, IL), version 20.0. In addition to descriptive statistics, independent t-test was performed to examine gender differences in each sagittal group. One-way analysis of variance (ANOVA) was used, followed by Bonferroni *post hoc* tests for multiple comparisons among the three groups in each gender-specific group.

RESULTS

The ICCs for the intraexaminer reliability were high for all measurements ($0.993 < r < 0.997$). Mean differences between the two readings ranged from 0.001 to 0.032 mm with no systematic errors of all the evaluated measurements.

The mean age was 21.9 ± 2.3 years. There was no statistically significant difference in the distribution of the mean ages of the patients within different sagittal classes ($p > 0.05$; chi-squared test).

The differences between males and females for each skeletal sagittal class were evaluated. The thickness at (Sn-A, Ls-Pr, U1-stom, lower lip thickness, upper lip height, nasal width, mouth width, intercanthal width, face width at Excanthion, face width at Subnasle, face width at Cheillion) was significantly greater in males than in females in the class I group. However, the measurements (lower lip height, labiomental fold thickness, chin thickness) did not show any significant difference between males and females in this group (Table 1). In class II group, significant differences were detected between males and females for Sn-A, Ls-Pr, lower lip thickness, face width at Exc, face width at Cheilion. These measurements were larger in males than in females. Regarding class III group, males exhibited greater values at Sn-A, Ls-Pr, lower lip thickness, nasal width, intercanthal width, face width at Exc, face width at Sn, face width at Cheilion compared to females (Table 2).

In males, significant differences were observed among the three sagittal classes for the following variables: U1-stom, nasal width, mouth width, which were larger in class I group than in class II group.

Lower lip thickness was larger in class I group than in class III group (Tables 3 and 4). In females, Sn-A, chin thickness, nasal width, mouth width, intercanthal width, face width at Sn, face width at Exc did not reveal any significant difference among the three sagittal classes. Whereas, the labiomental fold thickness and the upper lip height showed higher values in class II group than in class I group. U1-stom thickness was smaller in class I group than in class III group, LLH was greater in class I group than in class III group. Ls-Pr, U1-stom, face width at Cheilion revealed higher values in class III group than in class II group. Significant differences were also observed at lower lip thickness, ULH, LLH, as these three measurements showed greater values in class II group than in class III group (Tables 3 to 5).

DISCUSSION

To the best of our knowledge, this study seems to be the first to evaluate the soft tissue thicknesses and measurements in adult patients with different sagittal malocclusion classes for males and females using CBCT images retrospectively.

Numerous studies evaluating soft tissue norms for different populations with different chronological ages have shown that facial soft tissue thickness values are greater in males than in females.[2,3,19-21] Similar observations were reported in Celikoglu's study, which used CBCT images to compare soft tissue thickness at the lower anterior face in patients with different skeletal vertical patterns.[22]

In the present study, soft tissue thicknesses and measurements were greater in males than in females. However, statistically significant gender differences were not detected for all of the measurements in each sagittal class. Generally, women's skin lacks collagen synthesis and encourages synthesis of hyaluronic acid because of estrogen. On the other hand, men usually have thicker skin because testosterone encourages collagen synthesis.[3]

In the literature, several studies using conventional lateral cephalometric radiographs have explored facial soft tissue thickness in adult patients with various skeletal sagittal patterns.[21,23] However, lateral cephalometric films have been found to have severe flaws, including distortion, low reproducibility, differences in magnification, and the superimposition of bilateral craniofacial structures compared with the CBCT images.[20-25] Cone beam computed tomography technology has made it possible to achieve true (1:1 size) images without magnification and showed high intra- and interobserver reproducibility.[26,27]

In 2010, Utsuno et al[28] performed a pilot study on Japanese females to evaluate the differences in facial soft tissue thicknesses among three skeletal sagittal classes using cephalometric radiographs. The greatest difference was found between class II and III groups, with class I group being intermediate. Kurkcuoglu et al[23] conducted a similar study in adult Turkish subjects using cephalometric radiographs. The results showed that facial soft tissue thicknesses may vary among different craniofacial types. In females, the thickness at the upper lip and chin were the greatest in class III patients compared with the other skeletal types. In males, the soft tissue thickness at upper lip (A-Sn) was greater in individuals from class II and III groups compared to class I group. Similarly, Kamak and Celikoglu[2] found significant differences in soft tissue thickness among skeletal classes in a Turkish population, which were observed for the laberale superious, stomion, and laberale inferious sites in both males and females. The thickness at labrale superious and stomion points in each skeletal type was the greatest in class III group for both sexes. On the other hand, at the laberale inferious point, for both males and females, soft tissue depth was the lowest in class III group and the highest in class II group. Utsuno et al[29] found significant differences

Table 2: Mean and standard deviations for each variable according to the skeletal sagittal classification and gender. p-values of significance tests for the female–male comparisons are given

Class	*Class I*					*Class II*					*Class III*				
	Males		*Females*			*Males*		*Females*			*Males*		*Females*		
Variable[†]	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*p-value*[‡]	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*p-value*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*p-value*
Sn-A	15.74	1.92	13.61	2.44	0.0102*	15.21	2.08	13.30	1.72	0.008**	15.75	1.78	13.48	1.32	0.000**
Ls-Pr	16.12	3.12	12.80	2.11	0.001**	13.99	2.29	12.28	1.68	0.022*	17.56	3.87	13.83	1.39	0.001**
U1-stom	8.14	3.11	5.43	2.52	0.011*	4.71	3.04	3.89	1.50	0.346	8.11	2.18	7.29	1.74	0.246
B-Lm	12.29	2.56	11.06	2.15	0.151	12.33	3.42	13.21	2.81	0.432	12.49	2.27	11.35	1.66	0.116
Li-Id	18.37	2.47	14.41	2.88	0.000**	17.86	2.45	16.05	2.53	0.049*	15.93	2.23	13.78	2.17	0.009**
Pogs-Pog	9.93	1.49	8.99	3.05	0.278	8.66	2.02	9.38	1.84	0.301	8.71	1.67	8.42	2.05	0.660
ULH	21.74	2.22	19.65	1.89	0.008**	20.86	2.53	21.92	1.57	0.163	20.74	3.70	19.49	2.90	0.298
LLH	9.98	1.82	9.81	1.33	0.775	9.89	1.21	10.46	1.17	0.186	9.58	1.80	8.63	1.19	0.090
acR-acL	38.26	3.86	32.84	1.71	0.000**	35.04	2.87	34.48	2.08	0.530	37.61	2.75	34.19	2.17	0.000**
ChR-ChL	58.02	6.17	51.73	3.49	0.001**	52.31	4.25	51.51	4.06	0.590	54.57	3.23	51.97	4.85	0.085
ExcR-ExcL	94.01	4.99	89.26	3.52	0.004**	91.84	4.31	91.12	4.40	0.644	92.31	4.01	89.14	4.70	0.049*
Face width at exc	137.80	5.07	134.24	4.59	0.046*	136.71	2.95	133.66	3.50	0.012*	138.51	3.31	134.55	4.12	0.005**
Face width at Sn	133.19	6.73	127.23	4.99	0.008**	129.80	4.65	126.59	4.96	0.069	134.13	4.52	128.56	6.16	0.007**
Face width at Cheillion	125.23	9.01	117.82	6.10	0.011*	120.21	7.37	113.93	6.75	0.018*	128.80	6.42	120.51	6.40	0.001**

[†]The definitions of soft- and hard-tissue landmarks are given in Table 1; [‡]Applying two-sample t tests. $*p<0.05$; $**p<0.01$

Table 3: Mean and standard deviations of facial soft tissue measurements for both males and females for the three groups of sagittal class (n = 96)

Gender	*Males (n = 48)*						*Females (n = 48)*					
Class	*Class I*		*Class II*		*Class III*		*Class I*		*Class II*		*Class III*	
*Variable**	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
Sn-A	15.74	1.92	15.21	2.08	15.75	1.78	13.61	2.44	13.30	1.72	13.48	1.32
Ls-Pr	16.12	3.12	13.99	2.29	17.56	3.87	12.80	2.11	12.28	1.68	13.83	1.39
U1-stom	8.14	3.11	4.71	3.04	8.11	2.18	5.43	2.52	3.89	1.50	7.29	1.74
B-Lm	12.29	2.56	12.33	3.42	12.49	2.27	11.06	2.15	13.21	2.81	11.35	1.66
Li-Id	18.37	2.47	17.86	2.45	15.93	2.23	14.41	2.88	16.05	2.53	13.78	2.17
Pogs-Pog	9.93	1.49	8.66	2.02	8.71	1.67	8.99	3.05	9.38	1.84	8.42	2.05
ULH	21.74	2.22	20.86	2.53	20.74	3.70	19.65	1.89	21.92	1.57	19.49	2.90
LLH	9.98	1.82	9.89	1.21	9.58	1.80	9.81	1.33	10.46	1.17	8.63	1.19
acR-acL	38.26	3.86	35.04	2.87	37.61	2.75	32.84	1.71	34.48	2.08	34.19	2.17
ChR-ChL	58.02	6.17	52.31	4.25	54.57	3.23	51.7	3.5	51.5	4.1	52.0	4.9
ExcR-ExcL	94.01	4.99	91.84	4.31	92.31	4.01	89.3	3.5	91.1	4.4	89.1	4.7
FW at exc	137.80	5.07	136.71	2.95	138.51	3.31	134.2	4.6	133.7	3.5	134.6	4.1
FW at Sn	133.19	6.73	129.80	4.65	134.13	4.52	127.2	5.0	126.6	5.0	128.6	6.2
FW at Cheilion	125.23	9.01	120.21	7.37	128.80	6.42	117.8	6.1	113.9	6.8	120.5	6.4

*Landmarks' definitions are given in Table 1. FW: Facial Width

Table 4: Comparisons of facial soft tissue thicknesses for male subjects among the three groups of skeletal class (n = 48)

Variable†	*Skeletal class*	*Skeletal class*	*Mean difference*	*Standard error of the mean*	*p-value*‡
Ls-Pr	Class I	Class II	2.13	1.12	0.191
		Class III	–1.44	1.12	0.609
	Class II	Class III	–3.57	1.12	0.008**
U1-stom	Class I	Class II	3.43	0.99	0.004**
		Class III	0.02	0.99	1.000
	Class II	Class III	–3.41	0.99	0.004**
Li-Id	Class I	Class II	0.51	0.84	1.000
		Class III	2.44	0.84	0.018*
	Class II	Class III	1.93	0.84	0.081
acR-acL	Class I	Class II	3.22	1.13	0.020*
		Class III	0.65	1.13	1.000
	Class II	Class III	–2.57	1.13	0.084
ChR-ChL	Class I	Class II	5.71	1.67	0.004**
		Class III	3.45	1.67	0.132
	Class II	Class III	–2.26	1.67	0.543
Face width at exc	Class I	Class II	5.03	2.71	0.212
		Class III	–3.57	2.71	0.585
	Class II	Class III	–8.59	2.71	0.008**

†Landmarks' definitions are given in Table 1; ‡Bonferroni *post hoc* tests were applied following the use of one-way ANOVA among the three groups. *p < 0.05; **p < 0.01

Table 5: Comparisons of facial soft tissue thicknesses for female subjects among the three groups of skeletal class (n = 48)

Variable†	*Skeletal class*	*Skeletal class*	*Mean difference*	*Standard error of the mean*	*p-value*‡
Ls-Pr	Class I	Class II	0.53	0.62	1.000
		Class III	–1.03	0.62	0.310
	Class II	Class III	–1.56	0.62	0.047*
U1-stom	Class I	Class II	1.54	0.70	0.097
		Class III	–1.86	0.70	0.032*
	Class II	Class III	–3.39	0.70	0.000**
B-Lm	Class I	Class II	–2.14	0.80	0.030*
		Class III	–0.29	0.80	1.000
	Class II	Class III	1.86	0.80	0.073
Li-Id	Class I	Class II	–1.64	0.90	0.223
		Class III	0.63	0.90	1.000
	Class II	Class III	2.28	0.90	0.045*
ULH	Class I	Class II	–2.27	0.78	0.016*
		Class III	0.16	0.78	1.000
	Class II	Class III	2.43	0.78	0.009**
LLH	Class I	Class II	–0.65	0.43	0.426
		Class III	1.18	0.43	0.028*
	Class II	Class III	1.83	0.43	0.000**
Face width at exc	Class I	Class II	3.89	2.27	0.281
		Class III	–2.69	2.27	0.728
	Class II	Class III	–6.58	2.27	0.017*

†Landmarks' definitions are given in Table 1; ‡Bonferroni *post hoc* tests were applied following the use of one-way ANOVA among the three groups. *p < 0.05; **p < 0.01

among skeletal classes in Japanese population at points: Subnasale, labrale superious, stomtion, and gnathion.

The disagreement between the findings of this study and those of Utsuno, Kurkcuoglu, and Kamak might be due to racial differences. A review of the literature shows differences in soft tissue thicknesses among different racial groups. The sample in this study included subjects within a limited geographic area, minimizing the impact of ethnic differences on the results. Another reason for the disagreement might be that the previous researchers used conventional cephalometric films for their evaluation, whereas, CBCT images were used in the present study.

It is difficult to compare our findings of ULH, LLH, nasal width, mouth width, intercanthal width, face width at Exc, face width at Sn, face width at Cheillion among the skeletal classes with the findings of other studies because of the lack of any similar study evaluating these parameters. Pithon et al[21] compared facial soft tissue thicknesses in north eastern Brazilians, and found no difference among the skeletal classes except between class II and III groups for the points: Stomion, bottom lip, and pogonion. But Pithon's study was performed in young individuals, and therefore cannot be compared with the results of this study. In the future, it would be better to conduct a larger study involving a combination of these variables to compare these measurements for each skeletal class between children and adults.

CONCLUSION

- Sex-related differences in facial soft tissue thicknesses and measurements were observed in all the sagittal classes of malocclusion. However, statistically significant gender differences were not detected for all of the measurements in each sagittal class.
- Significant differences in facial soft tissue thicknesses and measurements were observed among the three sagittal classes. However, statistically significant differences were not detected for all of the measurements.

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