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A comparison of facial soft tissue thickness in Anatolian pre-pubertal and post-pubertal subjects in relation to different facial patterns

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Abstract

Objectives: Facial soft tissue thickness is important for forensic anthropologists, dentists and plastic surgeons. Forensic anthropologists use such information as a reference in facial reconstruction and superimposition. The purpose of this study was to measure facial tissue thicknesses separately for pre-puberty and post-puberty subjects with Turkish origins across different malocclusion types and to compare the results with each other and with values obtained for other races.

Methods: The study was conducted on 402 healthy subjects. Facial tissue thicknesses were measured at 10 cephalometric landmarks in a computerized environment. Gender-based variations in facial tissue thickness were noted in prepubertal and postpubertal subjects.

Results: Many facial tissue thickness values were observed to change in pre-puberty and post-puberty periods with respect to gender. In general, values were found to be higher in post-puberty males. Differences values were found to be the lowest for Class I and Class III females.

Conclusion: Facial tissue thickness in both pre-puberty and post-puberty periods changes with respect to malocclusion types.

Key words: facial soft tissue; forensic anthropology; malocclusion

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Introduction

The expression "facial tissue" is a very wide concept. The facial tissue extends from the epidermis, dermis and hypodermis layers of skin on the outer side to the bony tissue on the inner side. It also encompasses the periosteum of the bone, collagen and elastic fibers, blood vessels, nerves and sebaceous and perspiratory glands.[1] Facial harmony and balance are determined by both the skeleton and the soft tissue. However, most of the visual impact of the face is provided by the structure of the overlying soft tissues and their relative proportions. An evaluation of the relative contribution of the soft–tissue structures of the nose, lips and chin, as well as of the reciprocal spatial positions, will complete the hard tissue. Knowledge of soft tissue depths pertaining to the growth and development period is important for dentistry and forensic anthropology.[2] Forensic anthropologists use such knowledge to make a determination of the identity of the individual reference.[3] Hemler and Gruner used the important forensic anthropological method of superimposition for the first time to determine identity. In this method, they suggested that the distance between the face and soft tissue contours were determined so as to identify the face and facial maps be made accordingly.[4] Facial reconstruction, on the other hand, begins with the examination on skull and bones. Age and gender of the individual and also the suitable tissue thick-

nesses are determined. Pieces of skull are placed on certain points on the skull according to the tissue thicknesses; eye-sockets, forehead and the nasal septum which are different for each individual are precisely determined and the face is finalized according to the age and the gender.[5,6] For both methods used in forensic anthropology, one has to know the facial tissue thickness values.

In dentistry, the first step of putting a diagnosis and planning of the orthodontic treatment is the clinical examination of the patient and also good determination of the facial type and morphology. Holdaway stated that 'Better treatment goals can be set if we quantitate the soft tissue features which contribute to or detract from that physical attractivenees stereotype that has been ingrained into our culture".[6] Studies have indicated that facial tissue thickness differs with respect to age, gender and race. Therefore, collecting tissue measurement data from different populations and from individuals across different ages is important to determine the variability and to attain statistically reliable results.[5-7]

Data on soft tissue thickness are obtained from living organisms and cadavers by using different methods.[2,4,7,8] The simplest method to determine the soft tissue thickness is 'needle inserting method' which is used on cadavers and now considered as a primitive method. Cadavers lose 0.7 kg a day and the effect of such weight loss on soft tissue thickness requires the use of in vivo measurement methods.[3] With technological advancements, in vivo facial tissue thickness measurement is conducted by means of lateral cephalometric radiography,[9] ultrasonography (USG),[10,11] computerized tomography (CT)[12-14] and magnetic resonance imaging (MRI).[15] When Broadbent introduced his cephalometer in 1931, a new period began in orthodonticts. By using lateral cephalometric radiography, midfacial tissue thickness can be easily evaluated and this method is preferred more frequently due to its low radiation dose and high repeatability.[9,16]

Facial soft tissue thickness has been studied on various populations. When the results of the studies were evaluated independent form the soft tissue mesurement techniques, significant differences in facial soft tissue thickness were observed among the populations.[3] Interpopulation differences are important not only for identification in forensic anthropology, but also for treatment planning in orthodonty or for surgical approaches in plastic surgery. On the other hand, it is well known that facial soft tissue depths change with gender and age.[3,17] Though there are studies on facial soft tissue thickness in Turkish population, there is no detailed research in literature that presents differences between pre-pubertal and post-pubertal periods for the Turkish population. Existing studies have been directed to defining norms for different cephalometric analysis methods used in orthodonty rather than facial tissue thickness.[18-20]

The aims of this study can be summarized as follows: 1- Comparative identification of facial tissue thicknesses in pre-pubertal period with respect to malocclusion groups in both genders in Turkish population, 2- Comparative identification of facial tissue thicknesses in post-pubertal period with respect to malocclusion groups for genders in Turkish population, and 3- Comparison of changes in soft tissue thickness in pre-pubertal and post-pubertal periods with respect to gender for different malocclusion groups in Turkish population. We believe the findings of this study will be helpful for orthodontic treatments and surgical operations in Turkey, also support identity determination studies and reconstruction processes in forensic anthropology.

Materials and Methods

This retrospective study was conducted by utilizing the records of those who applied to Başkent University Faculty of Dentistry between 2008 and 2010 for orthodontic treatment. Participants and their families were Turkish and living in Anatolia. They were chosen so as to form a homogenous structure with respect to their geographical origins and economical status. Subjects showed normal growth and development with a symmetrical face, minimal crowding, no previous orthodontic, orthognathic, or prostodontic treatment and no craniofacial deformities or trauma. Individuals with obesity were also excluded from the study. Lateral cephalometric X-ray images of a total of 402 qualified individuals were taken by a digital Planmeca cephalometer (PM 2002 EC Proline, Helsinki, Finland). All subjects were positioned in the cephalostat on the sagittal plane at a right angle to the path of the x-rays and the Frankfort plane parallel to the horizontal, with the teeth in centric occlusion. X-ray film was placed parallel to mid-facial sagittal plane from a distance of 12.5 cm. Lateral cephalometric X-ray images were acquired with a 155-cm film-to-tube distance (USA 5 Feet = 152.5 cm) (75 kvp for 4.9 sec.). Lips were slightly closed in subjects with adequate lip closure and in patients with inconsistent lips, cephalograms were taken so as not to put any strain to the perioral muscles.

Patients were divided into two groups, pre-pubertal (n=203) and post-pubertal (n=199), by using cervical vertebrae maturation index (CV4 developmental stage) on lateral cephalometric radiographs. On the second stage, patients were subdivided into Class I, II, and III according to the following criteria: Skeletal Class I: Patients with an ANB angle of 2º±2, favorable overjet and overbite and minimal crowding of both arches. Class I represents a balanced profile, Skeletal Class II: Patients with an ANB angle of +5º or more, increased overjet. Class II represents retrognathic profile, Skeletal Class III: Patients with an ANB angle of -1º or less negative overjet. Class III represents prognathic profile. **Tables 1** and **2** show the pre-pubertal and post-pubertal groups with respect to class, age and gender.

The obtained lateral cephalometric X-ray images were stored in TIFF format in a personal computer's hard drive. All images were imported into Image-J software for the measurement of tissue parameters. Soft tissue thicknesses were measured from ten different points using the line tool of the software. A line spanning the whole cross-sectional profile of the soft tissue compartment perpendicular to the bone surface was drawn for each point and the length of the line was then measured by the menu command "Analyze>Measure". All data were stored in the internal spreadsheet of Image-J and then transferred to a Microsoft Excel spreadsheet for further analysis. For bilateral structures, a single average tracing was made. All the tracings were made by the same investigator.

Facial tissue thickness analysis included 20 landmarks (10 dentoskeletal and 10 soft tissue) and 10 linear variables. Descriptions of the measured parameters are given in **Table 3** and **Figure 1.** Descriptions of the measured variables are given in **Table 2.**

Table 1
Descriptive statistics for age in pre-pubertal group

	Class I	Class II	Class III
Females (age) n=101	11.639±1.432 n=33	11.382±1.303 n=34	11.558±1.877 n=34
Males (age) n=102	11.935±1.364 n=31	12.594±1.655 n=34	11.378±2.164 n=37

Table 2
Descriptive statistics for age in post-pubertal group

	Class I	Class II	Class III
Females (age) n=99	20.176±1.567 n=34	19.741±1.403 n=31	20.617+1.567 n=34
Males (age) n=100	16.410±1.876 n=34	17.777+2.619 n=36	19.633±5.391 n=30

Table 3
Cephalometric landmarks

1	Gls-Gl	Linear distance from the most prominent point on frontal bone to the soft tissue prominence on the forehead
2	Ns-N	Distance from point nasion to soft tissue nasion
3	Rh	Perpendicular distance from the intersection of nasal bone and cartilage to soft tissue.
4	Sn-A	Distance between subnasale and A point
5	Ls-Pr	Distance between the most prominent point of the upper lip and prosthion
6	St-U1	Distance between the most prominent point of the upper incisor and stomion (the median point of the oral slit when the mouth is closed)
7	Li-Id	Distance between the most prominent point of the lower lip and infradentale
8	Lm-B	Distance from B point to labiomental sulcus
9	Pogs-Pog	The distance between bony pogonion and soft tissue pogonion
10	Mes-Me	The distance between bony menton and soft tissue menton

Statistical analysis

Homogeneities of the groups' variances were controlled by Levene's test. The normality of the distribution of the parameters was controlled by Shapiro-Wilk test. Parametric test assumptions were invalid. Therefore, data set was analyzed by Mann-Whitney U test and Kruskal-Wallis one way analysis of variance by ranks test. Dunn test was used to perform multiple comparisons between pairs of groups. Results were given as mean ± standard deviation and median. P value of <0.05 was considered statistically significant. All statistical analyses were performed by using SPSS 13.0.

Results

Firstly, facial tissue thicknesses were observed across all facial profile types in both female and male groups. **Table 4** shows the mean and standard deviation for the facial tissue thicknesses of Turkish pre-pubertal children (values given for both genders). When the values for the females were evaluated, the highest standard deviation

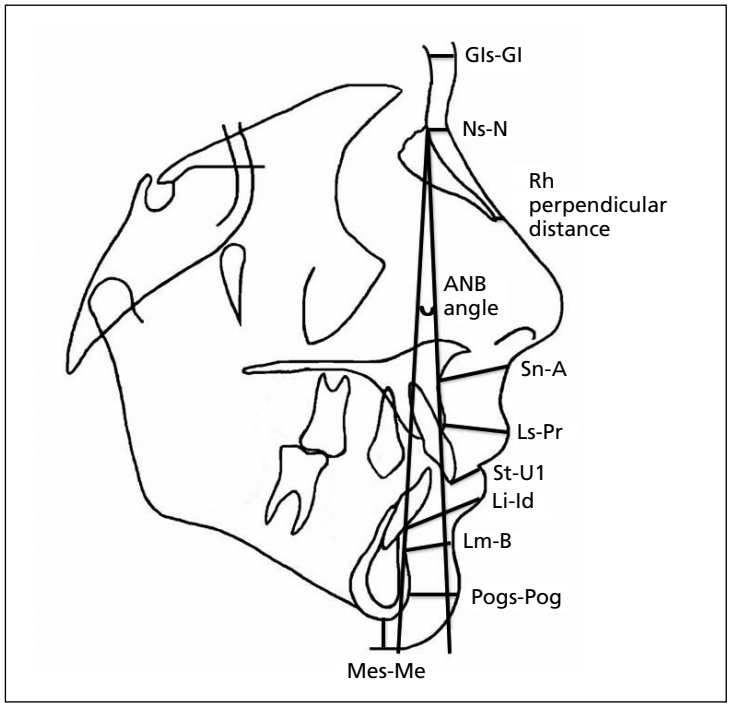

Figure 1. Radiological landmarks and ANB angle in Class II group on lateral cephalogram.

values were observed at the glabella point of the subjects with Class I and Class III.

However, for the subjects with Class II, the highest standard deviation was at Li-ld. Facial tissue thickness at rhinion (Rh perpendicular) showed the lowest variation across all categories of facial profile. The greatest difference between Class I, II, and III was observed at the stomion (contact point of upper and lower lips). For the male subjects, the highest standart deviation was observed at Rh for each category of facial profile types. On the other hand, contrary to the female individuals, glabella showed the lowest variation across all class in

Table 4
Descriptive statistics of cephalometric measurements for each skeletal type in pre-pubertal group (all measurement values in mm)

	Females				Males			
	Class I n = 33 $\bar{X}\pm S_{\bar{X}}$	Class II n = 34 $\bar{X}\pm S_{\bar{X}}$	Class III n = 34 $\bar{X}\pm S_{\bar{X}}$	p	Class I n = 31 $\bar{X}\pm S_{\bar{X}}$	Class II n = 34 $\bar{X}\pm S_{\bar{X}}$	Class III n = 37 $\bar{X}\pm S_{\bar{X}}$	p
Gls-Gl	5.43±0.89	5.35±0.80	5.57±0.81	ns	6.06±1.50	6.13±1.00	6.12±0.98	ns
Ns-N	4.79±1.77	4.44±1.26	4.76±1.77	ns	6.18±2.43[a]	4.94±1.51[b]	4.63±1.61[b]	<0.05
Rh	1.99±0.46[a]	1.96±0.37[a]	2.23±0.41[b]	<0.05	2.28±5.03	2.28±5.44	2.18±5.06	ns
Sn-A	15.24±2.09[a]	14.61±1.83[b]	16.38±2.45[c]	<0.01	16.01±2.18	14.87±2.58	15.44±3.94	ns
Ls-Pr	13.97±1.71[a]	13.01±1.68[b]	14.61±2.22[c]	<0.01	14.44±1.161	14.61±1.89	14.86±2.13	ns
St-U1	5.41±1.55[a]	4.20±1.54[b]	6.87±1.75[c]	<0.001	5.73±1.30[a]	4.85±1.79[b]	6.72±2.14[c]	<0.001
Li-Id	14.39±1.59	14.66±2.33	13.65±1.65	ns	15.41±1.99[a]	17.15±1.67[b]	14.10±2.23[c]	<0.001
Lm-B	10.26±1.31	10.26±1.98	10.05±1.18	ns	11.06±2.04[a]	11.70±2.20[b]	10.45±1.90[c]	<0.05
Pogs-Pog	9.60±2.14[a]	7.97±1.92[b]	8.82±2.18[c]	<0.05	9.22±2.71[a]	8.10±2.47[b]	7.89±1.73[b]	<0.05
Mes-Me	8.88±1.84	8.19±1.40	9.01±1.74	ns	8.88±2.06	9.03±2.07	8.69±1.52	ns

*a, b, c: Different letters represent the statistically significant differences between the group means according to ANCOVA (For all Lenin's F statistics ps >0.05)

males. When the groups with different facial profile types were compared to each other with respect to facial tissue thickness, the greatest differences were observed at stomion and Li-ld points. Contrary to the female subjects, no difference was found in males at Rh, Sn-A and Ls-Pr points from the point of midfacial tissue thickness.

When the post-pubertal female children were evaluated, considerable differences in soft tissue thicknesses were observed at Li-ld point among all skeletal types. Midfacial tissue thickness at Ls-Pr and pogonion points of Class III type individuals was considerably different from those of Class I and II skeletal type individuals. For the males, differences among the skeletal types with respect to soft tissue thickness were more pronounced when compared to females. As in females, the most significant difference among the skeletal types in males was observed at Li-ld point. Tissue thickness of the individuals of Class II type at stomion point was significantly lower than that of the individuals of Class I and III. However, for the female subjects, no significant differences were found among the skeletal types with respect to the tissue thickness at stomion point **(Table 5).**

Measurements for pre-pubertal and post-pubertal groups were also evaluated comparatively. Ingroup measurement results of pre-pubertal females were compared to each other as well. While the facial tissue thickness values at Rh point did not differ statistically between Class I and Class II groups, the value for Class III was found to be statistically higher than those for the other two groups. Sn-A, Ls-Pr, St-U1 and Pogs-Pog values across all three groups were found to be significantly different from each other.

As for pre-pubertal males, Ns-N and Pogs-Pog values of Class I were found to be significantly higher than those of Class II and Class III. For St-U1, Li-ld and Lm-B points, measurement values of the three groups were found to be different from each other.

For post-pubertal group girls, Ls-Pr and Pogs-Pog values for Class III were significantly higher than those for the other two groups and Li-Id value for Class II was higher than that for the other two groups.

In post-pubertal males, Li-Id and Mes-Me measurement values for all three groups were found to be different from each other. St-U1 and Ls-Pr values for Class II were observed to be different from those for the other two groups. Also Sn-A value for Class I was evaluated to be different from that for the other two groups.

Pre-pubertal and post-pubertal groups within the male and female groups were comparatively analyzed to investigate whether facial tissue thicknesses varied in between. Although each group yielded different results across classes, facial tissue thickness values of males were found to be generally higher than those of females. These measurement values are given in **Tables 6-8.** Inter-observer errors were examined. Measurements were repeated for two times to achieve reability in the measurements and intraobserver and intraclass correlation coefficients were obtained **(Table 9).**

Table 5
Descriptive statistics of cephalometric measurements for each skeletal type in post-pubertal group
(all measurement values in mm)

	Females				Males			
	Class I n = 33 $\bar{X}\pm S_{\bar{X}}$	Class II n = 34 $\bar{X}\pm S_{\bar{X}}$	Class III n = 34 $\bar{X}\pm S_{\bar{X}}$	p	Class I n = 31 $\bar{X}\pm S_{\bar{X}}$	Class II n = 34 $\bar{X}\pm S_{\bar{X}}$	Class III n = 37 $\bar{X}\pm S_{\bar{X}}$	p
Gls-Gl	5.41±0.72	5.51±0.75	5.82±1.07	ns	6.27±0.98	6.03±0.89	6.38±1.14	ns
Ns-N	4.25±1.22	5.51±1.70	4.70±1.45	ns	5.44±1.62[a]	5.51±1.59[a]	5.26±1.63[b]	<0.01
Rh	2.03±0.47	2.03±0.31	2.18±0.39	ns	2.63±0.63	2.45±0.55	2.38±4.45	ns
Sn-A	15.29±2.08	15.47±1.57	16.93±2.38	ns	16.88±3.53[a]	18.07±2.58[b]	17.75±3.31[b]	<0.01
Ls-Pr	13.04±1.98[a]	12.89±1.81[a]	14.26±1.94[b]	<0.05	16.31±1.88[a]	14.83±2.25[b]	16.14±2.28[a]	<0.01
St-U1	4.51±0.94	4.40±1.11	6.04±1.95	ns	6.38±2.19[a]	5.69±1.99[b]	6.41±2.06[a]	<0.001
Li-Id	14.56±1.26[a]	16.02±1.44[b]	14.06±1.90[a]	<0.001	17.13±1.94[a]	17.83±2.38[b]	15.12±2.24[c]	<0.001
Lm-B	10.91±1.52	11.55±2.24	11.05±1.26	ns	12.40±1.85	12.92±2.87	11.65±1.75	ns
Pogs-Pog	8.84±1.83[a]	8.63±2.09[a]	9.64±1.71[b]	<0.05	9.82±1.68	8.55±2.28	9.37±2.26	ns
Mes-Me	8.99±1.57	8.71±1.74	9.82±1.85	ns	10.78±0.17[a]	10.29±2.23[b]	9.97±2.10[c]	<0.05

Table 6
Descriptive statistics of cephalometric measurements for each skeletal type in post-pubertal group (all measurement values in mm)

	Females			Males		
	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p
Gls-Gl	5.43±0.89	5.41±0.72	ns	6.06±1.50	6.27±0.98	ns
Ns-N	4.79±1.77	4.25±1.22	ns	6.18±2.43	5.44±1.62	ns
Rh	1.99±0.46	2.03±0.47	ns	2.28±5.03	2.63±0.63	<0.05
Sn-A	15.24±2.09	15.29±2.08	ns	16.01±2.18	16.88±3.53	ns
Ls-Pr	13.97±1.71	13.04±1.98	<0.05	14.44±1.16	16.31±1.88	<0.001
St-U1	5.41±1.55	4.51±0.94	<0.05	5.73±1.30	6.38±2.19	ns
Li-Id	14.39±1.59	14.56±1.26	ns	15.41±1.99	17.13±1.94	<0.01
Lm-B	10.26±1.31	10.91±1.52	ns	11.06±2.04	12.40±1.85	<0.01
Pogs-Pog	9.60±2.14	8.84±1.83	ns	9.22±2.71	9.82±1.68	ns
Mes-Me	8.88±1.84	8.99±1.57	ns	8.88±2.06	10.78±0.17	<0.001

Table 7
Comparison of facial soft tissue thickness values between pre-pubertal and post-pubertal subjects for both genders in Class II group (all measurement values in mm)

	Females			Males		
	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p
Gls-Gl	5.35±0.08	5.51±0.75	ns	6.13±1.00	6.03±0.89	ns
Ns-N	4.44±1.26	5.51±1.70	<0.01	4.94±1.51	5.51±1.59	ns
Rh	1.96±0.37	2.03±0.31	ns	2.28±5.44	2.45±0.55	ns
Sn-A	14.61±1.83	15.47±1.57	ns	14.87±2.58	18.07±2.58	<0.001
Ls-Pr	13.01±1.68	12.89±1.81	ns	14.61±1.89	14.83±2.25	ns
St-U1	4.20±1.54	4.40±1.11	ns	4.85±1.79	5.69±1.99	<0.05
Li-Id	14.66±2.33	16.02±1.44	<0.01	17.15±1.67	17.83±2.38	ns
Lm-B	10.26±1.98	11.55±2.24	<0.05	11.70±2.20	12.92±2.87	ns
Pogs-Pog	7.97±1.92	8.63±2.09	ns	8.10±2.47	8.55±2.28	ns
Mes-Me	8.19±1.40	8.71±1.74	ns	9.03±2.07	10.29±2.23	<0.01

Table 8
Comparison of facial soft tissue thickness values between pre-pubertal and post-pubertal subjects for both sexes in Class III group (all measurement values in mm)

	Females			Males		
	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p	Pre-pubertal $\bar{X}\pm S_{\bar{X}}$	Post-pubertal $\bar{X}\pm S_{\bar{X}}$	p
Gls-Gl	5.57±0.81	5.82±1.07	ns	6.12±0.98	6.38±1.14	ns
Ns-N	4.76±1.77	4.70±1.45	ns	4.63±1.61	5.26±1.63	ns
Rh	2.23±0.41	2.18±0.39	ns	2.18±5.06	2.38±4.45	ns
Sn-A	16.38±2.45	16.93±2.38	ns	15.44±3.94	17.75±3.31	<0.05
Ls-Pr	14.61±2.22	14.26±1.94	ns	14.86±2.13	16.14±2.28	ns
St-U1	6.87±1.75	6.04±1.95	<0.05	6.72±2.14	6.41±2.06	ns
Li-Id	13.65±1.65	14.06±1.90	ns	14.10±2.23	15.12±2.24	ns
Lm-B	10.05±1.18	11.05±1.26	<0.01	10.45±1.90	11.65±1.75	<0.01
Pogs-Pog	8.82±2.18	9.64±1.71	ns	7.89±1.73	9.37±2.26	<0.01
Mes-Me	9.01±1.74	9.82±1.85	ns	8.69±1.52	9.97±2.10	<0.01

Table 9
Intraclass correlations for intraobserver measurements

	Inter-Item correlations	Intraclass correlations	p
Gls-Gl	0.844	0.914	<0.001
Ns-N	0.877	0.936	<0.001
Rh	0.484	0.652	<0.01
Sn-A	0.803	0.725	<0.001
Ls-Pr	0.798	0.873	<0.001
St-U1	0.486	0.651	<0.01
Li-Id	0.993	0.850	<0.001
Lm-B	0.685	0.735	<0.001
Pogs-Pog	0.488	0.623	<0.01
Mes-Me	0.935	0.966	<0.001

In Class I individuals, changes were more prominent in male subjects. In females, only a slight decrease was observed in the soft tissue thicknesses at Ls-Pr and stomion points. However, for the males, increases in the tissue thicknesses were observed at Ls-Pr, Mes-Me, Li-Id, Lm-B, and Rh points. Although the most prominent differences were observed at Ls-Pr and Mes-Me points in males, no significant difference was observed in the soft tissue thickness at Mes-Me point between pre-pubertal and post–pubertal in females.

For Class II type females, significant increases in the facial soft tissue thicknesses were observed at Ns-N, Li-Id, and Lm-B points. However, for the male increases in the soft tissue thicknesses were significant at Sn-A, St-U1, and Mes-Me points. Although the most prominent increase in the midfacial tissue thickness with puberty was observed at Sn-A point in the male subjects, no considerable increase was observed at that point in female subjects.

In Class III skeletal type, facial soft tissue changes that occur in male subjects with the advance of puberty were marked. An increase was observed at Sn-A, Lm-B, Pogs-Pog, and Mes-Me points for the male subjects. On the other hand, increases in the soft tissue thicknesses were observed only at St-U1 and Lm-B points in the female subjects.

Discussion

For years anthropologists have tried to determine identities just by making use of remains of bones. Afterwards, world standards for tissue thicknesses of adults were developed to be applied on facial reconstruction operations. Earlier in this century, Broadbent et al. conducted studies on the growth and development of the tissue encompassing the maxillofacial area.[21] As the lateral radiographs started to be used, the normal expectations on the growth of dentofacial complex were found and this was very useful especially for the dentists. Recent studies conducted by Farkas and Munro also contributed to our knowledge.[22]

Facial tissue thickness has been studied in different populations. Studies were done on adults in European, American, African and Japanese populations, however these were regardless of the facial type.[15-17] Values pertaining to the Turkish population are limited to the dentistry literature and existing studies have been conducted to find out the norm values of specific orthodontic analyses.[18-20,23-25] In one of these studies, Erbay et al. used various linear lines and angles on Turkish adult subjects with Anatolian origins who pertained to Class I group. They measured the distance between the soft tissue parts of the upper and lower lips and these lines and compared measurements for males and females. However, they did not come up with a significant difference between the genders and they did not make any measurements related to facial tissue thickness.[23]

In another study performed in accordance with Holdaway analysis norms by Erbay et al., it was found that the value for the lower lip was similar to the standard proposed by Holdaway, whereas the values for the nasal prominence and the H angle were greater than Holdaway's norms.[23] Başçiftçi et al. measured 175 individuals to determine Holdaway soft tissue norms on Turkish adults of Anatolian origins. This study was conducted only on patients with Class I group. In conclusion, they stated that their values were generally consistent with Holdaway soft tissue norms, however only the values obtained for chin and upper lips were different.[20]

In another study from Turkey, Şahin and Gazilerli carried out measurements on Class I group female and male children (9-12 years) by making use of various lines and angles.[24] They found that, while the soft-tissue facial angle, basic upper lip thickness, nose prominence, lower lip sulcus depth and soft-tissue Pogonion thickness measurements increased in boys and girls due to age, skeletal profile convexity and H angle measurements showed a decrease. In addition, the decrease in H angle in girls was significant. Increases in basic upper lip and upper lip thickness measurement values were more significant in boys than in girls. In this study, we have found that upper lip soft tissue thickness (Ls-Pr) differed among classes for pre-pubertal females and that the highest value was observed at Class III. For pre-pubertal males, this value

did not differ among classes. Li-Id (lower lip soft tissue thickness) value did not differ among classes for females, whereas Class II displayed the highest value in males. In conclusion, in consistence with the findings of the studies conducted by Gazilerli et al., we have found that both values (Ls-Pr and Li-Id) were found to be higher in males than in females. When Pogonion soft tissue thickness measurement values were evaluated, no significant difference was observed between females and males in Class I and Class II groups, on the other hand a statistically significant difference was noted between pre-pubertal and post-pubertal Class III males. The post-pubertal group values were found to be higher.

Apart from these studies, no detailed study presenting especially the pre-puberty and post-puberty differences for the Turkish population has been found in the literature. In this study, facial tissue thickness norms were attempted to be determined for pre-pubertal and post-pubertal individuals with Anatolian origins and for various facial types with respect to gender. The obtained data were analyzed to find out whether there were variations related to facial types and gender.

Age, gender and dental malocclusion patterns are factors that affect the facial tissue thickness.[1,6,8,12] In this study, we have used 10 landmarks. Facial tissue thicknesses at Gls-Gl, Ns-N, Rh, Sn-A, Ls-Pr, St-U1, Li-ld, Lm-B, Pogs-Pog and Mes-Me distances were found to vary with respect to gender and puberty; these were higher in males and in the post-pubertal group and tissue thickness increased with age accordingly. These values were observed to change according to the dental malocclusion patterns.

Not all individuals in societies have balanced facial profiles. People in most of the societies have Class I and orthognathic facial type. Seen less frequently is the Class II group and retrognathic facial type where the upper chin is anterior and the lower chin is posterior to their normal positions in relation to each other. Seen even less frequently is the Class III group and prognathic facial type where the upper chin is posterior and the lower chin is anterior to their normal positions in relation to each other. Therefore, it has been considered necessary that subjects were divided into groups according to their facial types while determining differences between pre-pubertal and post-pubertal periods. In some soft tissue thicknesses measurement studies that used cephalometric films, radiographs were drawn manually, making use of conventional methods.[25]

The findings of this study have been compared to those of former studies on subjects from different populations and some similarities were observed between the mentioned findings. Al-Gunaid et al. conducted soft tissue thickness measurements for the Yemeni esthetically pleasing male subjects (YPG) and repaining male subjects (YNG) and also they compared the two mentioned groups to the white Americans and found significant differences in between.[26] YPG were found to have a significantly less convex profile than the YNG. Upper-lip thickness and skeletal profile convexity values for both groups were found to be significantly higher than Holdaway norms. Two of the norms observed in their study are also found in our study. Ls-Pr and Mes-Me measurement values were compared to those of Yemeni adult males. Soft tissue average thickness values for Yemeni males at Ls-Pr point were stated to be congruent with those for post-pubertal Class II male subjects in our study and that soft tissue thickness values at Mes-Me point were found as 11.4+2.1 mm for YPG group and 12.2+2.0 mm for YNG group. These values were found to be lower than those of all three Classes in our study. When these results are considered, it can be said that adult Yemeni males have more prominent chin structures than the Turkish population.

In a similar study, Aulsebrook et al. measured facial soft tissue thicknesses for the Zulu male adults by using sixteen different landmarks.[8] However, in this study subjects were not divided into classes. We compared their findings to ours for the post-pubertal male group. Although Pogs-Pog, Lm-B, Li-ld, St-U1 and Ls-Pr values for Class I post-pubertal group of the Turkish population and the adult Zulu males are very similar, values for Mes-Me, Sn-A, Rh and Ns-N points were higher for the Zulus, on the other hand Gls-Gl value was higher for the Turkish population. These results indicate that soft tissue of Zulu males were thicker than those of the Turks. Utsuno et al. reported in his study that, at three points in the upper face region (Gls-Gl, Ns-N, and Rh), no differences were evident among the three classes, and based on his findings, they have suggested that soft tissue depth did not vary where the soft tissue was adherent to the bone.[27] In the present study, similar to the results of with the study by Utsuno et al., no significant differences were found among the classes for facial soft tissue thickness in the upper facial region in female postpubertal group. However, in the postpubertal male subjects, the tissue depth at Ns-N point was significantly lower in Class III group.[27]

Dumont studied facial tissue thickness in males and females in American Whites (Class I) and compared their findings with other studies in black Americans, Europeans and the Japanese.[28-31] The findings pertaining to the adolescent group were different. The most important reason for such differences found among the results of these studies was the methodology used. In these studies, facial tissue thicknesses were evaluated by means of radiographic methods and cadaver measurements and cephalometric measurements were found to be higher than cadaver measurements. On practices performed on cadavers "needle inserting method" was employed. Although used widely, there are many drawbacks of this method. One of these is the determination of bone land markers and the inability/incapacity to perform a facial typing accurately. Another drawback is that such differences observed in facial tissue thickness values for adults may be due to racial and regional differences. It was reported that tissue distortion existed even in cadavers operated within the first 12 hours and that cadavers lost 1.5 Ibs (0.7 kg) in a day and that such a loss affected the soft tissue measurement values.[3] For example, the time period between the death of the Europeans and the Japanese and data collection was not short. Therefore, the values were observed to be lower than the results obtained by other measurement methods. In conclusion, it is reasonable to say that the needle inserting method is not a suitable method for facial tissue measurements. Evaluation of cephalometric measurements that had been used in other studies was also performed by manual measurement. The method employed in our study is different from those where we performed soft tissue thickness measurements by using digital radiographs, computerized environment, and Image-J software which we believed to carry a low error margin. Our method saved us time in the drawings of a 400 people wide data group and it cleared away chemical bath errors as well. Polat-Özsoy et al. in their studies showed that the use of digital radiograph eliminated chemical bath defects met with the use of conventional radiographs and that measuring errors were evaded completeley with the use of a computerized analysis method.[25]

Dumont measured also pre-pubertal group values separately and found various differences between such values and the values of the existing study.[28] For Class I pre-pubertal females, Gls-Gl, Ns-N, Rh, Sn-A and Lm-B values were lower and Mes-Me value was higher in the Turkish population. Ls-Pr and Pogs-Pog values for the Turkish population and Dumont's group were proximate. Class I pre-pubertal Turkish male group was compared to American White males between the ages of 9 to 12; Ns-N, Rh, Sn-A and Lm-B values were evaluated to be lower and, Mes-Me value higher in in the Turkish population and Gls-Gl, Ls-Pr and Pogs-Pog values were similar in these groups. Of these studies conducted through cephalometric measurements, our measurements were done in a computerized environment whereas Dumont's measurements were performed manually. The study showed similar results, on the other hand the fact that different results were obtained made us think that it could be caused by both racial and regional variations.

Utsuno et al. calculated facial tissue thickness measurement values of Class I Japanese children by making use of points similar to those used in our study. In their study, age intervals were established and measurements were performed to present differences with respect to these intervals.[31] Japanese pre-pubertal group male and female groups were compared to those of the Turkish population. Lm-B and Pogs-Pog values were higher for the Japanese for both genders, Gls-Gl, Li-ld and Sn-A values were higher for the Turks for both genders, Rh and Ls-Pr values were low for the Turkish population, St-U1 value was low for the Japanese and Ns-N values of both populations were similar to each other. The results of post-pubertal group comparisons were as follows: N-Ns, Rh, Lm-B and Pogs-Pog values were higher for the Japanese females and males, Gl, Sn-A, Ls-Pr and St values were higher for the Turkish population, Li-Id value for females Li-Id value for males were lower for the Turkish population when compared to the Japanese. As these results suggested, there were differences between the Turkish and Japanese populations with respect to the facial tissue measurements. These differences were thought to be emanated from the fact that individuals reached puberty at different ages within the mentioned populations. We know individuals living in countries close to equator reach puberty earlier than those living in northern countries, and because the nose and the tip of the chin grow at a marked rate at puberty, these measurements are expected to have high values for the Turkish population. However, the fact that measurements for the tip of the chin for the Japanese was higher can be explained by the fact that prognathic structure is observed more frequently in the Japanese.

In a study done by Manhein et al. on Hispanic females and males (9-13 years old), all facial measurement values for the male group were found lower than those for our Class I male group and that N-Ns was thicker in Turkish females than in Hispanic females. We

compared their findings pertaining to 14-18 year old females to those in Turkish post-puberty females. It was found that facial tissue thickness in the lower half of the face was lower for the post-pubertal Turkish females and those on the lips and chin area were higher for Turkish males.[32] These findings are considered to be due to differences among populations studied.

Conclusion

In conclusion, in this study many significant differences in facial tissue thicknesses were found for many points among classes for both females and males and for both pre-pubertal and post-pubertal periods. In the pre-pubertal females these differences were prominent on the upper part of the face, whereas in males they were prominent on the lower part of the face. As for the post-pubertal period, differences in tissue thicknesses among female groups were more prominent around the lips; differences in tissue thicknesses among male groups were more prominent on the midfacial area and menton. Differences in tissue thickness values in males between pre-puberty and post-puberty periods were prominent at more points than those in females. If gender can be determined by means of all these measurements, then the appropriate tissue thicknesses and 3 dimensional reconstructions can be used as a data source for superimposition and 2 dimensional drawings. Relying on these data, more accurate identification and reconstruction on pre-pubertal and post-pubertal males and females are also possible.

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