

Comparisons of Soft Tissue Thickness Measurements in Adult Patients With Various Vertical Patterns

Farklı Vertikal Paternlere Sahip Bireylerde Yumuşak Doku Kalınlıklarının Değerlendirilmesi

Neslihan Seyhan Cezairli

Ordu University Faculty of Dentistry, Department of Orthodontics, Ordu, Turkey



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Anahtar Kelimeler

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Address for Correspondence/Yazışma Adresi:

Neslihan Seyhan Cezairli MD,
Ordu University Faculty of Dentistry,
Department of Orthodontics, Ordu, Turkey
Phone : +90 452 212 50 11
E-mail : nesli_seyhan_13@hotmail.com
ORCID ID: orcid.org/0000-0001-8750-4161

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Abstract

Objective: The purposes of this study were to evaluate to study soft tissue facial profile among the different vertical patterns using the Holdaway analysis and the soft tissue thickness measurements.

Materials and Methods: The study sample consisted of 90 patients divided into 3 groups: low angle group (30 patients; mean age, 20.38±3.76 years), normal angle group (30 patients; mean age, 19.36±2.83 years) and high angle group (30 patients; mean age, 19.44±2.14 years). The study sample, comprised a total of 90 patients (54 women and 36 men) divided into low-angle, normal-angle and high angle groups based on vertical growth pattern using the SN/GoGn angle (high-angle group >37°; low-angle group <27°; and control group or normal angle group 27-37°). Facial soft-tissue thickness and Holdaway measurements were analyzed on each radiograph with Image J programme. One-way analysis of variance and post-hoc test (Tukey) were used to compare Holdaway measurements and soft tissue thicknesses among the three groups.

Results: Significant differences among vertical patterns were observed for the 'gnathion', 'menton', 'stomion' and 'inferior sulcus to H line' when both genders were combined. These measurements were thinner in the high-angle group. Significant differences among vertical patterns were observed for 'gnathion' and 'lower lip to H line' in women; for 'stomion' and 'nose prominence' in men when examined separately.

Conclusion: Facial soft tissue measurements except some for in high angle group were thinner than in low angle group. All soft tissue measurements were greater except for gnathion in low angle group in men than in women.

Öz

Amaç: Bu çalışmanın amacı, Holdaway analizi ve yumuşak doku kalınlık ölçümleri kullanılarak farklı vertikal paternlerde yumuşak doku profilini değerlendirmektir.

Gereç ve Yöntemler: Doksan hastadan oluşan çalışma grubu SN/GoGn açısı kullanılarak vertikal gelişim paternine göre 3 gruba ayrıldı (hiperdiverjan>37°; hipodiverjan<27°; ve kontrol grup veya normodiverjan 27-37°); hipodiverjan (30 hasta; ortalama yaş, 20,38±3,76 yıl), normodiverjan (30 hasta; ortalama yaş, 19,36±2,83 yıl) ve hiperdiverjan (30 hasta; ortalama yaş, 19,44±2,14 yıl). Yüz yumuşak doku kalınlık ölçümleri ve Holdaway ölçümleri her bir radyograf üzerinde Image J programı ile yapıldı. Üç grup arasında yumuşak doku ve Holdaway ölçümleri arasındaki fark, one-way analysis of variance ve post-hoc test (Tukey) ile değerlendirildi.

Bulgular: Vertikal paternler arasında 'gnathion', 'menton', 'stomion' and 'inferior sulcus to H line' ölçümlerinde, cinsiyet ayrımı yapılmaksızın değerlendirildiğinde istatistiksel olarak önemli bir fark bulundu. Cinsiyet ayrımı yapıldığında ise kadınlarda 'gnathion' and 'lower lip to H line' ölçümlerinde, erkeklerde 'stomion' and 'nose prominence' ölçümlerinde istatistiksel olarak anlamlı fark bulundu.

Sonuç: Sadece hiperdiverjandaki bazı ölçümler hariç tüm yumuşak doku kalınlık ölçümleri hipodiverjan en az bulundu. 'Gnathion' ölçümü hariç diğer tüm yumuşak doku ölçümleri ise erkeklerde kadınlardan daha fazla bulundu.

Introduction

It is generally accepted that there is a relationship between occlusal forces and facial morphology. Three basic types of facial morphology exist: short face, average, and long face. Long face has excessive vertical facial growth and typically associated with anterior open bite and an increased maxillary/mandibular planes angle, sella-nasion/mandibular plane angle and gonial angle (1). Short face has decreased vertical growth and typically accompanied by deep bite, reduced facial heights, and decreased SN/mandibular plane angle (2). Average face has normal vertical pattern angles (3). The relationship between bite force and craniofacial morphology has been studied (4). Average face subjects have higher bite force in molar region as compared with long face subjects, while short face subjects had still higher maximum forces than the normal face subjects (4).

The changes that occur in the soft-tissue profile during orthodontic treatment have played a significant role in the diagnosis and treatment planning process (5). Facial harmony and balance are determined by the facial skeleton and its soft tissue drape. Most previous studies were routinely used to evaluate the position of the teeth in relation to the skeletal components. However, sporadic attempts were made to include an element of soft tissue profile assessment, such as Ricketts (6) esthetic plane, Holdaway (7) analysis and Burstone's (8) soft tissue analysis.

Previous studies have studied facial soft tissue thickness in Japanese children having different skeletal classes (9,10). Utsuno et al. (9) indicated that measurements differed among these various classes. Several studies have made similar measurements in the Turkish population (11-13). Bascifci et al. (11) made a study to determine Holdaway soft tissue norms in Anatolian Turkish adults and found significant differences between genders for soft tissue chin thickness and upper lip thickness. Kamak and Celikoglu (14) found that soft tissue thickness at all regions was higher in men than in women.

The purposes of this study was to evaluate the soft tissue facial profiles among the different vertical patterns using the Holdaway analysis and the soft

tissue thickness measurements, compare all values with the Holdaway soft-tissue norms of Anatolian Turkish adults and to determine any sexual differences between the soft tissue facial profile of men and women in each vertical group.

Materials and Methods

This study was designed to evaluate the differences in soft-tissue characteristics as determined by the Holdaway soft-tissue analysis of orthodontic patients and to determine the soft tissue thickness of orthodontic patients with different vertical growth patterns. This study was approved by the Ethics Committee of Karadeniz Technical University Faculty of Medicine (ethics committee approval no: 2013/91). A total of 90 patients (36 boys and 54 girls), referred to the Department of Orthodontics at the Karadeniz Teknik University Faculty of Dentistry, were included in this study. The study sample, comprised a total of 90 patients aged 20-26 years divided into low-angle, normal-angle and high angle groups based on vertical growth pattern using the SN/GoGn angle (high-angle group $>37^\circ$; low-angle group $<27^\circ$; and control group or normal angle group $27-37^\circ$). The images used in the present study were part of the diagnostic records collected due to dental treatment need. Lateral cephalometric radiographs were taken from all patients. The age of the subjects ranged between 20-26 years, with a mean age of 20.38 ± 3.76 years, 19.36 ± 2.83 years and 19.44 ± 2.14 years in groups 1, 2 and 3, respectively. Gender and age distributions are shown in Table 1. All subjects were selected on the basis of the following criteria:

- Balanced facial profiles with competent lips,
- No history of previous orthodontic treatment,
- No congenitally missing teeth,
- Subjects with skeletal Class I malocclusions ($1^\circ < ANB < 5^\circ$),
- Subjects with different vertical relationships (SN/GoGn= $32 \pm 6^\circ$),
- Nongrowing patients.

The subjects were divided into three groups based on SN/GoGn° angle. All patients had skeletal Class I ($1^\circ < ANB < 5^\circ$) malocclusions.

- Group 1 included 30 hipodiverjant subjects,
- Group 2 included 30 normodiverjant subjects,
- Group 3 included 30 hiperdiverjant subjects.

The radiographs were analyzed by the same researcher. Eighteen linear and two angular measurements were analyzed on each radiograph with Image J software. The landmarks were located according to the definition provided by Holdaway (15). The following measurements were used (Figures 1 and 2):

- H line: Tangent drawn from the tip of the chin to the upper lip;
- Soft tissue facial angle (STA): The downward and inner angle formed at a point where the sella-nasion line crosses the soft tissue and a line combining the suprapogonion with the Frankfort horizontal plane;

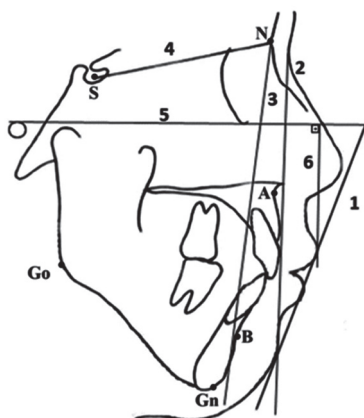


Figure 1. The planes used: (1) H line or harmony line: drawn tangent to the soft tissue chin and the upper lip. (2) Soft tissue facial line: drawn from soft tissue nasion to the point on the soft tissue chinoverlying Ricketts suprapogonion. (3) Hard tissue facial plane. (4) Sella-nasion line. (5) Frankfort horizontal plane. (6) A line running at a right angle to the Frankfort plane down tangent to the vermillion

Table 1. Comparison of the demographic variables among different vertical patterns

	N	Female/ Male	Mean Age (Years)	ANB°	SN/GoGn°
High-angle group	30	19/11	19.44±2.14	3.08±1.39	39.66±2.14
Low-angle group	30	18/12	20.38±3.76	2.63±1.76	24.72±2.05
Normal-angle group	30	17/13	19.36±2.83	2.75±1.05	31.07±2.37
Total	90	54/36			
p			NS		

NS: Not significant, ANB: Angle between NA and NB lines, SN/GoGn: Angle between SN and GoGn lines

Table 2. Comparison of facial soft-tissue thickness measurements between the sexes in each group

Measurements	Group	Gender	Mean ± SD	p
Pogonion	Group 1	Female	10.7±1.87	0.161
		Male	11.71±1.90	
	Group 2	Female	10.36±1.66	0.015*
		Male	12.02±1.81	
	Group 3	Female	10.29±1.76	0.037*
		Male	11.94±2.34	
Gnathion	Group 1	Female	8.95±2.60	0.763
		Male	8.69±1.87	
	Group 2	Female	7.45±1.37	0.072
		Male	8.42±1.43	
	Group 3	Female	6.70±1.88	0.264
		Male	7.41±1.01	
Menton	Group 1	Female	7.81±2.03	0.255
		Male	8.62±1.58	
	Group 2	Female	6.65±1.11	0.058
		Male	7.66±1.66	
	Group 3	Female	6.52±1.84	0.121
		Male	7.59±1.61	
Glabella	Group 1	Female	5.52±0.95	0.393
		Male	5.79±0.57	
	Group 2	Female	5.39±0.73	0.154
		Male	5.82±0.86	
	Group 3	Female	5.34±0.79	0.224
		Male	5.84±1.42	
Nasion	Group 1	Female	5.58±6.67	0.025*
		Male	6.67±1.38	
	Group 2	Female	5.25±0.94	0.011*
		Male	6.28±1.11	
	Group 3	Female	5.24±0.99	0.117
		Male	5.89±1.15	
Rhinion	Group 1	Female	1.54±0.40	0.033*
		Male	2.18±1.10	
	Group 2	Female	1.51±0.38	0.019*
		Male	1.92±0.51	
	Group 3	Female	1.31±0.43	0.016*
		Male	1.77±0.52	
Subnasale	Group 1	Female	14.08±1.47	0.001***
		Male	16.77±2.32	
	Group 2	Female	5.25±0.94	0.001***
		Male	6.28±1.11	
	Group 3	Female	14.03±1.97	0.001***
		Male	16.77±1.67	
Stomion	Group 1	Female	4.63±1.70	0.001***
		Male	6.90±1.55	
	Group 2	Female	3.56±1.49	0.005**
		Male	5.35±1.73	
	Group 3	Female	4.06±1.86	0.949
		Male		

Table 2. continue				
		Male	4.11±1.33	
Labrale inferior	Group 1	Female	12.55±1.88	0.001***
		Male	15.14±1.95	
	Group 2	Female	11.47±2.06	0.000***
		Male	14.47±1.23	
	Group 3	Female	12.10±1.24	0.006**
		Male	13.80±1.88	
Labiomentale	Group 1	Female	10.30±1.06	0.240
		Male	10.88±1.55	
	Group 2	Female	10.05±1.60	0.058
		Male	11.09±1.15	
	Group 3	Female	10.28±1.40	0.013*
		Male	11.63±1.26	
Soft-tissue facial angle	Group 1	Female	84.83±21.48	0.392
		Male	90.29±3.19	
	Group 2	Female	88.60±2.65	0.695
		Male	88.20±2.83	
	Group 3	Female	88.44±2.56	0.356
		Male	87.44±3.23	
H angle	Group 1	Female	12.03±5.91	0.575
		Male	13.26±5.69	
	Group 2	Female	12.52±2.80	0.016*
		Male	15.51±3.57	
	Group 3	Female	14.68±3.85	0.576
		Male	15.44±2.84	
Nose prominence	Group 1	Female	14.63±3.74	0.927
		Male	14.73±1.59	
	Group 2	Female	15.31±2.68	0.148
		Male	13.89±2.48	
	Group 3	Female	14.69±2.42	0.008
		Male	16.53±3.08	
Soft-tissue subnasale to H line	Group 1	Female	3.08±1.74	0.471
		Male	3.68±2.76	
	Group 2	Female	2.56±1.59	0.088
		Male	3.89±2.51	
	Group 3	Female	3.49±2.29	0.126
		Male	4.75±1.72	
Inferior sulcus to H line	Group 1	Female	4.50±1.87	0.096
		Male	5.80±2.23	
	Group 2	Female	4.58±1.54	0.340
		Male	5.15±1.66	
	Group 3	Female	3.61±1.51	0.485
		Male	4.00±1.31	
Lower lip to H line	Group 1	Female	1.26±0.86	0.225

- Lower lip to H line (LLH): The measurement of the lower lip to the H line;
- H angle: The angle formed between the soft-tissue facial plane line and the H line;
- Skeletal profile convexity (SPC): The dimension between point A and facial line;
- Nose prominence (NP): The dimension between the tip of the nose and a perpendicular line drawn to the Frankfort plane from the vermilion;
- Soft tissue subnasale (Sn) to H line: The distance from Sn to H line;

Table 2. continue				
		Male	0.88±0.74	
	Group 2	Female	0.54±0.54	0.075
		Male	1.11±1.12	
	Group 3	Female	1.14±0.88	0.646
		Male	1.29±0.74	
Upper-lip thickness	Group 1	Female	10.55±1.93	0.008**
		Male	12.45±1.47	
	Group 2	Female	9.54±2.41	0.000***
		Male	12.83±1.47	
	Group 3	Female	9.80±1.45	0.001***
		Male	11.80±1.57	
Basic upper-lip thickness	Group 1	Female	12.65±1.64	0.004**
		Male	14.82±2.11	
	Group 2	Female	11.38±1.86	0.000***
		Male	14.76±1.47	
	Group 3	Female	11.57±1.73	0.002**
		Male	14.14±2.40	
Upper-lip sulcus depth	Group 1	Female	1.44±1.29	0.644
		Male	1.67±1.29	
	Group 2	Female	0.85±0.69	0.058
		Male	1.48±1.05	
	Group 3	Female	1.26±1.07	0.821
		Male	1.34±0.51	
Skeletal profile convexity	Group 1	Female	1.65±1.06	0.281
		Male	2.23±1.82	
	Group 2	Female	1.53±0.96	0.338
		Male	1.96±1.44	
	Group 3	Female	1.96±1.32	0.462
		Male	2.36±1.53	

*p<0.05, **p<0.01, ***p<0.001
NS: Not significant, SD: Standard deviation

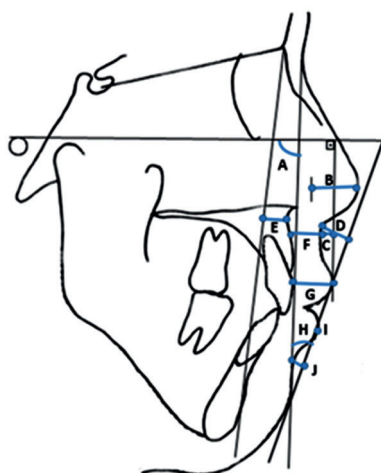


Figure 2. The angular and linear measurements: (A) Soft tissue facial angle: The inner angle formed by the intersection of soft tissue nasion-soft tissue suprapogonion line with the Frankfort horizontal plane. (B) Nose prominence: The distance from a line perpendicular to Frankfort horizontal and running tangent to the vermillion border of the upper lip to the tip of the nose. (C) Superior sulcus depth: Measured to a perpendicular to Frankfort and tangent to the vermillion border to the upper lip. (D) Soft tissue subnasale to H line: The distance from subnasale to H line. (E) Skeletal profile convexity: Measurement from point A to the hard tissue line Na-Pog. (F) Basic upper lip thickness: The distance from a point about 3 mm below point A to the drape of the upper lip. (G) Upper lip thickness: The distance from the labial surface of upper incisors to the vermillion border of the upper lip. (H) H angle: Angular measurement of the H line to the soft tissue facial plane. (I) Lower lip to H line: The distance from the lower lip to H line. (J) Inferior sulcus to the H line: Measured at the point of greatest incurvation between the vermillion border of the lower lip and the soft tissue chin and is measured to the H line

- Upper lip sulcus depth (USD): The measurement between the upper lip sulcus and a perpendicular line drawn from the vermillion to the Frankfort plane;
- Inferior sulcus to the H line (lower lip sulcus depth) (ISH): The measurement at the point of greatest convexity between the vermillion border of the lower lip and the H line;
- Basic upper-lip thickness (BULT): The dimension measured approximately three mm below point A and the drape of the upper lip;
- Upper-lip thickness (ULT): The dimension between the vermillion point and the labial surface of the upper incisor;
- Pogonion (Pog): Length between bony Pog and its horizontal projection (Pog') over the vertical passing through soft tissue pogonion.
- Gnathion (Gn): Distance between bony Gn and soft tissue (Gn').
- Menton (Me): Distance between bony Me and its vertical projection (Me') on the horizontal passing through soft tissue menton.
- Glabella (G): Length between bony G and its horizontal projection (G') over the vertical passing through soft tissue glabella.
- Nasion (N): Length between bony N and its horizontal projection (N') over the vertical passing through soft tissue nasion.
- Rhinion (Rhi): Length between bony Pog (Rhi) and its horizontal projection (Rhi') over the vertical passing through soft tissue Rhi.

Table 3. Comparison of the Holdaway measurements among the groups

	Anatolian Turkish norms	Holdaway norms	Group 1 Mean ± SD	Group 2 Mean ± SD	Group 3 Mean ± SD	p
STA	87.31±8.84	91±7	87.02±16.78	88.41±2.65	88.08±2.81	0.849
NP, mm	18.74±3.59	14 to 24	14.67±3.03	14.60±2.66	15.36±2.78	0.511
USD, mm	2.97±1.53	3 (1 to 4)	1.53±1.28	1.19±0.97	1.29±0.89	0.448
STSH, mm	5.12±3.33	5±2	3.32±2.18	3.27±2.20	3.95±2.16	0.406
SPC, mm	-0.21±2.31	0	1.88±1.41	1.73±1.17	2.11±1.39	0.530
BULT, mm	16.64±2.43	15	13.52±2.10	12.84±2.35	12.51±2.33	0.221
ULT, mm	13.96±2.7	13 to 14	11.31±1.98	11.02±2.59	10.53±1.76	0.375
H angle	13.75±3.01	10 (7 to 14)	12.52±5.76	13.92±3.44	14.96±3.48	0.100
LLH, mm	0.03±1.91	0 to 0.5 (1 to 2)	1.11±0.83	0.79±0.86	1.20±0.82	0.139
ISH, mm	6.2±2.3	No norms	5.02±2.08	4.80±1.57	3.75±1.43	0.012*

*p<0.05, p<0.01; p<0.001

SD: Standard deviation, STA: Soft tissue facial angle, NP: Nose prominence, USD: Upper lip sulcus depth, STSH: Soft tissue subnasale to H line, SPC: Skeletal profile convexity, BULT: Basic upper-lip thickness, ULT: Upper-lip thickness, LLH: Lower lip to H line, ISH: Inferior sulcus to the H line

- Subnasale (Sn): The distance between point A and subnasale.

- Stomion (Sto): The shortest distance between the upper incisor and the attachment points of the upper and lower lip.

- Labrale inferior (Li): The distance between infradentale and the vermilion border of the lower lip;

- Labiomentale (Labm): The distance between point B and the deepest point of the Labm crease.

Descriptive statistics (mean and standard deviation) were calculated using the SPSS program version 12.0 (SPSS Inc, Chicago, Ill). One-way analysis of variance (ANOVA) and post-hoc test (Tukey) were used to compare Holdaway measurements and soft tissue thicknesses among the three groups. Age difference among the groups was also evaluated with ANOVA. Comparison of differences between genders within each group was achieved with the Student's t-test. The level of significance was established at 5%.

Results

Table 1 shows the demographic data of the patients included to the groups. The groups were statistically well matched on vertical relationships. All groups had corresponding vertical cephalometric measurement (high-angle group, $39.66 \pm 2.14^\circ$; low-angle group, $24.72 \pm 2.05^\circ$; and normal-angle group, $31.07 \pm 2.37^\circ$). Age was not statistically significantly different across the three groups.

Student's t-test was used to compare men with women for each group. Table 2 compares the mean and standard deviation of the soft-tissue thicknesses between men and women in each group. Statistically significant differences were found only for the variable basic upper lip thickness, upper lip thickness, Pog, Rhi, Sn, Labiale inferior, labiomentale in high-angle group; for the variables basic upper lip thickness, upper lip

Table 4. Comparison of the soft tissue thickness and Holdaway values with different vertical patterns

	Group 1	Group 2	Group 3	p	Tukey		
					I-II	I-III	II-III
Pog	11.10±1.92	11.10±1.87	10.90±2.11	0.896	1.000	0.914	0.912
Gn	8.85±2.30	7.86±1.43	6.96±1.63	0.001**	0.093	0.000***	0.140
Me	8.13±1.88	7.09±1.42	6.91±1.81	0.015*	0.051	0.020*	0.916
G	5.83±0.82	5.62±0.82	5.52±1.07	0.881	0.998	0.888	0.914
N	6.01±1.32	5.70±1.11	5.48±1.08	0.213	0.546	0.188	0.749
Rhi	1.79±0.81	1.66±0.50	1.48±0.51	0.151	0.692	0.129	0.484
Sn	15.16±2.26	15.13±2.28	15.04±2.27	0.977	0.999	0.977	0.986
Sto	5.54±1.97	4.36±1.79	4.08±1.66	0.006**	0.035*	0.007**	0.818
Li	13.59±2.27	12.77±2.25	12.72±1.69	0.203	0.283	0.253	0.996
Labm	10.53±1.29	10.48±1.48	10.77±1.48	0.694	0.988	0.790	0.700
Holdaway measurements							
STA	87.02±16.78	88.41±2.65	88.08±2.81	0.849	0.847	0.910	0.990
H angle	12.52±5.76	13.92±3.44	14.96±3.48	0.100	0.424	0.083	0.624
NP, mm	14.67±3.03	14.60±2.66	15.36±2.78	0.511	0.994	0.611	0.542
STSH, mm	3.32±2.18	3.27±2.20	3.95±2.16	0.406	0.997	0.502	0.450
ISH, mm	5.02±2.08	4.80±1.57	3.75±1.53	0.012	0.876	0.015	0.050
LLH, mm	1.11±0.83	0.79±0.86	1.20±0.82	0.139	0.294	0.919	0.145
ULT, mm	11.31±1.98	11.02±2.59	10.53±1.76	0.375	0.861	0.349	0.652
BULT, mm	13.52±2.10	12.84±2.35	12.51±2.33	0.221	0.473	0.204	0.842
ULT, mm	1.53±1.28	1.19±0.97	1.29±0.89	0.448	0.434	0.656	0.933
SPC, mm	1.88±1.41	1.73±1.17	2.11±1.39	0.530	0.887	0.790	0.500
USD, mm	1.53±1.28	1.19±0.97	1.29±0.89	0.448	0.434	0.656	0.933

*p<0.05, **p<0.01, ***p<0.001

Pog: Pogonion, Gn: Gnathion, Me: Menton, G: Glabella, N: Nasion, Rhi: Rhinion, Sn: Subnasale, Sto: Stomion, Li: Labrale inferior, Labm: Labiomentale, STA: Soft tissue facial angle, NP: Nose prominence, STSH: Soft tissue subnasale to H line, ISH: Inferior sulcus to the H line, LLH: Lower lip to H line, ULT: Upper-lip thickness, BULT: Basic upper-lip thickness, SPC: Skeletal profile convexity, USD: Upper lip sulcus depth

thickness, nasion, Rhi, Sn, Sto, labiale inferior in low-angle group; for the variables basic upper lip thickness, upper lip thickness, Pog, H angle, Nasion, Rhi, Sn, Sto, Labiale inferior in normal angle group between the genders. The thickness values for male were higher in all vertical growth patterns compared with the values for female. Therefore female and male were separately examined for further comparisons.

Table 3 shows norms of Anatolian Turkish adults and comparisons of three studied groups for Holdaway soft-tissue values.

The results of this study showed that, except for four variables, all vertical groups have the same soft tissue norms as reported by Holdaway (Table 3).

Table 4 compares the mean and standard deviation of the soft tissue measurements among the studied groups. Four variables (the thickness values

at the 'Gn', 'Me', 'Sto' and 'ISH') showed statistically significant differences and higher in low-angle group compared with the values in the high-angle group ($p=0.001$, 0.015 , 0.006 and $p=0.012$, respectively).

The comparison of soft tissue thickness values for women and men are shown in Tables 5-6. Two variables showed statistically significant differences for both women and men. For women, the thickness values at the 'Lower lip-H line' and 'Gn' was found to be statistically significantly higher in the low-angle group (1.26 ± 0.86 mm and 8.95 ± 2.60 mm, respectively) compared with the values in the normal-angle group (0.55 ± 0.53 mm and 7.45 ± 1.33 mm, respectively). For men, the thickness value at the 'Nose prominence' in the high-angle group and at the 'Sto' in the low-angle group were found to be statistically significantly higher compared with the values in the normal-angle group.

Table 5. Comparison of the soft tissue thickness and Holdaway values for female subjects with different vertical patterns

	Group 1	Group 2	Group 3	p	Tukey HSD		
					I-II	I-III	II-III
Pog	10.70±1.87	10.44±1.65	10.29±1.76	0.780	0.902	0.764	0.963
Gn	8.95±2.60	7.45±1.33	6.70±1.88	0.005**	0.074	0.004**	0.494
Me	7.81±2.03	6.68±1.09	6.52±1.84	0.055	0.128	0.067	0.958
G	5.52±0.95	5.47±0.79	5.34±0.79	0.786	0.980	0.779	0.882
N	5.58±1.12	5.28±0.93	5.24±0.99	0.549	0.651	0.572	0.993
Rhi	1.54±0.40	1.48±0.40	1.31±0.43	0.237	0.886	0.228	0.465
Sn	14.08±1.47	14.00±1.72	14.03±1.97	0.991	0.990	0.996	0.998
Sto	4.63±1.70	3.65±1.50	4.06±1.86	0.233	0.205	0.578	0.738
Li	12.55±1.88	11.54±2.02	12.10±1.24	0.228	0.200	0.710	0.596
Labm	10.30±1.06	10.04±1.56	10.28±1.40	0.808	0.825	0.998	0.852
Holdaway measurements							
STA	84.83±21.48	88.56±2.58	88.44±2.56	0.595	0.644	0.655	1.000
H angle	12.03±5.91	12.78±2.92	14.68±3.85	0.176	0.866	0.169	0.394
NP, mm	14.63±3.74	15.11±2.74	14.69±2.42	0.872	0.882	0.998	0.905
STSH, mm	3.08±1.74	2.83±1.91	3.49±2.29	0.601	0.927	0.807	0.579
ISH, mm	4.50±1.87	4.55±1.50	3.61±1.51	0.154	0.996	0.200	0.234
LLH, mm	1.26±0.86	0.55±0.53	1.14±0.88	0.019*	0.023*	0.884	0.066
ULT, mm	10.55±1.93	9.71±2.45	9.80±1.45	0.385	0.421	0.491	0.990
BULT, mm	12.65±1.64	11.45±1.82	11.57±1.73	0.082	0.105	0.153	0.975
USD, mm	1.44±1.29	0.98±0.87	1.26±1.07	0.458	0.430	0.873	0.723
SPC, mm	1.65±1.06	1.56±0.94	1.96±1.32	0.516	0.964	0.678	0.517

* $p<0.05$, ** $p<0.01$

Pog: Pogonion, Gn: Gnathion, Me: Menton, G: Glabella, N: Nasion, Rhi: Rhinion, Sn: Subnasale, Sto: Stomion, Li: Labrale inferior, Labm: Labiamental, STA: Soft tissue facial angle, NP: Nose prominence, STSH: Soft tissue subnasale to H line, ISH: Inferior sulcus to the H line, LLH: Lower lip to H line, ULT: Upper-lip thickness, BULT: Basic upper-lip thickness, SPC: Skeletal profile convexity, USD: Upper lip sulcus depth

Soft tissue thickness values at the lower anterior face (Pog', Gn', Me') were the lowest in the high-angle group for both women and men.

Discussion

In the literature, there are few studies with which the pre-and posttreatment and extraction treatment Holdaway soft-tissue measurements can be directly compared. Few studies have also been carried out to assess the soft tissue thickness in adult patients with different vertical growth patterns (16,17). In our study, we also used Holdaway (15) analysis because it presents the soft tissue more in details with simplicity and directness in mind, and it is widely used for evaluation of soft tissue profiles.

The vertical groups included in the study were statistically well matched on gender distribution.

Because statistically significantly greater values were found for soft tissue thickness measurements in male than in female, further comparisons were done separately for women and men to eliminate the effect of gender on findings. In the present study the thickness values for men were higher in all vertical growth patterns compared with the values for the women except for 'LLH' and 'Gn-Gn' in low-angle group and 'Soft tissue angle' in N group. But statistically significant differences were found only for the thicknesses at Rhi, N, Sto, basic upper lip thickness, upper lip thickness, Li and Sn in low-angle group; at Pog, N, Rhi, subnasale, stomion, H angle, upper lip thickness, BULT and Li in normal-angle group and at Pog, Rhi, subnasale, nose prominence, upper lip thickness, basic upper lip thickness, Li and labiomentale in high-angle group between women

Table 6. Comparison of the soft tissue thickness and Holdaway values for male subjects with different vertical patterns

	Group 1	Group 2	Group 3	p	Tukey		
					I-II	I-III	II-III
Pog	11.71±1.90	12.02±1.81	11.94±2.34	0.926	0.923	0.959	0.995
Gn	8.69±1.87	8.42±1.43	7.41±1.01	0.113	0.893	0.115	0.240
Me	8.62±1.58	7.66±1.66	7.59±1.61	0.238	0.313	0.296	0.995
G	5.79±0.57	5.82±0.86	5.84±1.42	0.993	0.997	0.992	0.998
N	6.67±1.38	6.28±1.11	5.89±1.15	0.324	0.706	0.292	0.721
Rhi	2.18±1.10	1.92±0.51	1.77±0.52	0.442	0.694	0.418	0.871
Sn	16.77±2.32	16.69±2.07	16.77±1.67	0.994	0.995	1.000	0.995
Sto	6.90±1.55	5.35±1.73	4.11±1.33	0.001***	0.046*	0.000***	0.144
Li	15.14±1.95	14.47±1.23	13.80±1.88	0.186	0.591	0.160	0.611
Labm	10.88±1.55	11.09±1.15	11.63±1.26	0.391	0.913	0.375	0.592
Holdaway measurements							
STA	90.29±3.19	88.20±2.83	87.44±3.23	0.083	0.222	0.083	0.819
H angle	13.26±5.69	15.51±3.57	15.44±2.84	0.346	0.391	0.443	0.999
NP, mm	14.73±1.59	13.89±2.48	16.53±3.08	0.039*	0.666	0.198	0.033
STSH, mm	3.68±2.76	3.89±2.51	4.75±1.72	0.533	0.973	0.537	0.658
ISH, mm	5.80±2.23	5.15±1.66	4.00±1.31	0.065	0.645	0.055	0.268
LLH, mm	0.88±0.74	1.11±1.12	1.29±0.74	0.560	0.801	0.533	0.882
ULT, mm	12.45±1.47	12.83±1.47	11.80±1.57	0.258	0.800	0.565	0.231
BULT, mm	14.82±2.11	14.76±1.47	14.14±2.40	0.669	0.997	0.696	0.730
USD, mm	1.67±1.29	1.48±1.05	1.34±0.51	0.747	0.897	0.727	0.937
SPC, mm	2.23±1.82	1.96±1.44	2.36±1.53	0.822	0.907	0.980	0.817

*p<0.05, ***p<0.001

Pog: Pogonion, Gn: Gnathion, Me: Menton, G: Glabella, N: Nasion, Rhi: Rhinion, Sn: Subnasale, Sto: Stomion, Li: Labrale inferior, Labm: Labiomental, STA: Soft tissue facial angle, NP: Nose prominence, STSH: Soft tissue subnasale to H line, ISH: Inferior sulcus to the H line, LLH: Lower lip to H line, ULT: Upper-lip thickness, BULT: Basic upper-lip thickness, SPC: Skeletal profile convexity, USD: Upper lip sulcus depth

and men. According to Uysal et al. (18), statistically significant gender differences were found for the thickness of the labrale superius, labrale inferius, Pog and menton measurements. Celikoglu et al. (17) found that the soft tissue thickness measurements at the lower anterior face for men were higher in all vertical growth patterns compared with the values for the women. In another study they found that all soft tissue thickness measurements in men were higher than those in women (19). However, statistically significant gender differences were not found for all values in each skeletal class (Class I, Class II, Class III). The previous studies (20-22) has shown that the soft-tissue thicknesses of male patients were significantly greater than those of female patients, although some had no statistically significant difference. 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 (22). Macari and Hanna (16), except for gender differences in high angle group, found thicker soft tissue in all aspects of the face in men compared with women. The exception in high angle group might be related to the similar effect of the soft tissue at the chin (STC) reduction in subjects with the most hyperdivergence and increased lower face height.

Taki et al. (23) reported that significant differences were found in nose prominence, upper lip thickness, basic upper lip thickness, ISH, and soft tissue chin thickness measurements in comparison of sexes and the soft tissue chin thickness was significantly larger in male than in female. Similar results were obtained by Bascifci et al. (11) who reported that Anatolian Turkish men have a more distinctive chin than women. Conversely Baum (24) found that soft-tissue growth tendencies are different between the two sexes. Baum's (24) studies of children between 11 and 14 years of age indicate that girls develop at an earlier age than boys and tend to achieve a mature adult face earlier. Therefore, in this study to limit growth effects on lip thickness and lip strain, an effort was made to select subjects who have a similar age.

In the literature, few studies (16,17) using conventional lateral cephalometric radiographs and cone-beam computed tomography investigated soft tissue chin thickness in adult patients with various mandibular divergence patterns. In the present study

soft tissue facial profile was investigated for different vertical patterns using the Holdaway analysis and soft tissue thickness values.

The H angle measures the prominence of the upper lip in relation to the overall soft-tissue profile (15). As the skeletal convexity increases, the H angle must also increase if a harmonious drape of soft tissues is to be realized in varying degrees of profile convexity. Our results showed that the SPC and H angle were larger than Holdaway norms in group 3, indicating that high angle people have a slightly more convex profile compared with other groups. Also, the BULT and ULT were decreased in all groups in relation to Holdaway norms. Hajighadimi et al. (25) found that Persians have a more convex soft tissue profile compared with Tweed's and Steiner's standards and Taki et al. (23) found that Persian adults have slightly more convex profiles when compared with Holdaway norms. Bascifci et al. (11) found that H angle showed a significant decrease during the orthodontic treatment and becomes closer to the Anatolian Turkish norms.

The present study aimed to compare the soft tissue thicknesses of orthodontic patients with different vertical patterns. In this study statistically significant differences were found 'Gn', 'Me', 'Sto' and 'ISH' values among the vertical groups when both genders were combined and these were higher in the low-angle group. Whereas statistically significant differences were found for 'LLH' and 'Gn' values in women, statistically significant differences were found for 'Sto' and 'NP' values in men when examined separately. We found that whereas 'Gn' values were the thinnest in the high-angle group, 'LLH' values were the thinnest in the normal-angle group for women and 'Sto' measurements were the thinnest in the high-angle group for men. The thickness measurements at the Gn and menton were thinner in the high-angle group when both genders were combined.

Macari and Hanna (16) evaluated the association between STC thickness and mandibular divergence. They found statistically significantly difference at 'Gn' and 'Me' but not at 'Pog' that suggests the presence of a differential extension between hard and soft tissues during growth. However, the difference for Gn was statistically significant for both women and men when examined separately. The STC thickness apparently adapts to severe hyperdivergence, presumably through increased stretching of the STC in children with progressive increase in facial divergence.

Celikoglu et al. (17) compared the soft tissue thickness values at the lower anterior face among the adult patients with different vertical growth patterns using cone-beam computed tomography and 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, inferius, and Pog values for women, whereas the differences among the vertical groups were not significant for the men. In addition, women in the low-angle and normal-angle groups showed similar thickness values.

Conclusion

Significant differences in soft tissue thickness among vertical patterns were investigated for the gnathion, menton and Sto when both genders were combined. These measurements were thinner in the high-angle group.

Significant differences in soft tissue thickness among vertical patterns were observed for the Gn in women; for the Sto in men, when examined separately.

Significant differences in Holdaway measurements among vertical patterns were observed for 'inferior sulcus to H line' when both genders were combined. 'ISH' was thinner in the high-angle group.

Significant differences in Holdaway measurements among vertical patterns were observed for 'LLH' in women; for 'nose prominence' in men when examined separately.

In low angle group all soft tissue measurements were greater in men than in women, except for gnathion.

Ethics

Ethics Committee Approval: This study was approved by the Ethics Committee of Karadeniz Technical University Faculty of Medicine (ethics committee approval no: 2013/91).

Informed Consent: It was taken.

Peer-review: Externally peer-reviewed.

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References

- Fields HW, Proffit WR, Nixon WL, Phillips C, Stanek E. Facial pattern differences in long-faced children and adults. *Am J Orthod* 1984; 85: 217-23.
- Opdebeeck H, Bell WH. The short face syndrome. *Am J Orthod* 1978; 73: 499-511.
- Edgerton VR. Neuromuscular adaptation to power and endurance work. *Can J Appl Sport Sci* 1976; 1: 49-58.
- Proffit WR, Fields HW, Nixon WL. Occlusal forces in normal- and long-face adults. *J Dent Res* 1983; 62: 566-70.
- Garner LD. Soft tissue changes concurrent with orthodontic tooth movement. *Am J Orthod* 1974; 66: 367-77.
- Ricketts RM. Planning treatment on the basis of facial pattern and an estimate of its growth. *Angle Orthod* 1957; 27: 14-37.
- Holdaway RA. Changes in relationship of points A and B during orthodontic treatment. *Am J Orthod* 1956; 42: 176-93.
- Burstone CJ. Integumental contour and extension patterns. *Angle Orthod* 1959; 23: 146-57.
- Utsuno H, Kageyama T, Uchida K, Yoshino M, Miyazawa H, Inoue K. Facial soft tissue thickness in Japanese children. *Forensic Sci Int* 2010; 199: 109.
- Utsuno H, Kageyama T, Uchida K, Yoshino M, Oohigashi S, Miyazawa H, et al. Pilot study of facial soft tissue thickness differences among three skeletal classes in Japanese females. *Forensic Sci Int* 2010; 195: 165.
- Basciftci FA, Uysal T, Buyukerkmen A. Determination of Holdaway soft tissue norms in Anatolian Turkish adults. *Am J Orthod Dentofacial Orthop* 2003; 123: 395-400.
- Erbay EF, Caniklioğlu CM. Soft tissue profile in Anatolian Turkish adults: Part II. Comparison of different soft tissue analyses in the evaluation of beauty. *Am J Orthod Dentofacial Orthop* 2002; 121: 65-72.
- Erbay EF, Caniklioğlu CM, Erbay SK. Soft tissue profile in Anatolian Turkish adults: Part I. Evaluation of horizontal lip position using different soft tissue analyses. *Am J Orthod Dentofacial Orthop* 2002; 121: 57-64.
- Kamak H, Celikoglu M. Facial soft tissue thickness among skeletal malocclusions: is there a difference? *Korean J Orthod* 2012; 42: 23-31.
- Holdaway RA. Soft-tissue cephalometric analysis and its use in orthodontic treatment planning. *Am J Orthod* 1983; 84: 1-28.
- Macari AT, Hanna AE. Comparisons of soft tissue chin thickness in adult patients with various mandibular divergence patterns. *Angle Orthod* 2014; 84: 708-14.
- Celikoglu M, Buyuk SK, Ekizer A, Sekerci AE, Sisman Y. Assessment of the soft tissue thickness at the lower anterior face in adult patients with different skeletal vertical patterns using cone-beam computed tomography. *Angle Orthod* 2015; 85: 211-7.
- Uysal T, Yagci A, Basciftci FA, Sisman Y. Standards of soft tissue Arnett analysis for surgical planning in Turkish adults. *Eur J Orthod* 2009; 31: 449-56.
- Celikoglu M, Buyuk SK, Sekerci AE, Ersoz M, Celik S, Sisman Y. Facial soft-tissue thickness in patients affected by bilateral cleft lip and palate: a retrospective cone-beam computed tomography study. *Am J Orthod Dentofacial Orthop* 2014; 146: 573-8.
- Hamdan AM. Soft tissue morphology of Jordanian adolescents. *Angle Orthod* 2010; 80: 80-5.
- Kalha AS, Latif A, Govardhan SN. Soft-tissue cephalometric norms in a South Indian ethnic population. *Am J Orthod Dentofacial Orthop* 2008; 133: 876-81.
- Cha KS. Soft-tissue thickness of South Korean adults with normal facial profiles. *Korean J Orthod* 2013; 43: 178-85.
- Taki AA, Oguz F, Abuhijleh E. Facial soft tissue values in Persian adults with normal occlusion and well-balanced faces. *Angle Orthod* 2009; 79: 491-4.
- Baum AT. Age and sex differences in the dentofacial changes following orthodontic treatment and their significance in treatment planning. *Am J Orthod* 1961; 47: 355-69.
- Hajjghadimi M, Dougherty HL, Garakani F. Cephalometric evaluation of Iranian children and its comparison with Tweed's and Steiner's standards. *Am J Orthod* 1981; 79: 192-7.