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Standards of soft tissue Arnett analysis for surgical planning in Turkish adults

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SUMMARY The aims of this study were (1) to establish standards for Arnett soft tissue cephalometric analysis of Anatolian Turkish young adults and (2) to identify possible gender differences between males and females. After analysing the cephalometric radiographs of 350 individuals, 133 subjects (67 males, mean age 22.6 ± 2.2 years, and 66 females, mean age 22.1 ± 2.6 years) with normal antero-posterior and vertical skeletal relationships were selected. The true vertical line was established. The landmarks were marked and soft tissue facial analysis was performed. For statistical evaluation, an independent-samples *t*-test was used.

The lower lip thickness of the Turkish population was lower and menton thickness was greater than Arnett's norms. Turkish subjects have depressed orbital rims, cheek bones, subpupils, upright and thin upper and lower lips, retruded incisors, and pogonion and point B. Most of the Turkish mean harmony values were within the range of Arnett's harmony standards. Soft tissue thicknesses were greater and facial lengths, except upper incisor exposure, were longer in Turkish males than females. These differences between ethnic groups should be taken into consideration when formulating orthodontic/orthognathic treatment plans for patients with dentofacial deformity.

Introduction

Diagnosis and treatment planning are necessary for successful treatment of malocclusions. Diagnosis is the definition of the problem and treatment planning is based on diagnosis and is the process of planning changes needed to eliminate the problems (Arnett and Bergman, 1993a,b). A combination of soft tissue cephalometric and clinical examinations is necessary to successfully diagnose and plan treatment for facial changes (Arnett and Bergman, 1993a,b; Arnett and McLaughlin, 2004).

After standardization of the radiographic technique by Broadbent (1931), the importance of soft tissue facial analysis was considered secondary and dentoskeletal relationships became a deciding factor in diagnosis and treatment planning.

Many authors have suggested utilizing soft tissue analysis as a reliable guide for occlusal treatment and attendant soft tissue changes (Burstone, 1958, 1967; Legan and Burstone, 1980; Holdaway, 1984; Arnett and Bergman, 1993a,b; Arnett *et al.*, 1999; Bergman, 1999; Arnett and McLaughlin, 2004). Cosmetic changes created with surgical techniques require focusing on areas which enhance surgical results. Tweed (1944), Riedel (1957), Burstone (1958, 1967), Steiner (1959), and Ricketts *et al.* (1982) noted that nose length, lip length, and nasolabial angle were important aspects of facial aesthetics. However, they did not specifically use the examination to be considered in surgical diagnosis and treatment planning. Arnett and Bergman (1993a,b) presented the 'facial keys to orthodontic diagnosis and treatment planning' as a three-dimensional clinical blueprint for soft tissue analysis and treatment planning. Arnett *et al.* (1999) suggested that the soft tissue profile is a critical guide to tooth placement, occlusal correction, and optimum facial harmony. Achieving optimum facial harmony is the treatment goal of this 'soft tissue cephalometric analysis (STCA)'. It assists the clinician in accurately identifying subjects requiring surgery and helps to improve the likelihood of a successful outcome.

According to Hwang *et al.* (2002), attempts have been made to investigate the differences in the faces of various ethnic groups including American blacks (Richardson, 1980), Africans (Jacobson, 1978; Kapila, 1989), Brazilians (Cerci *et al.*, 1993), Chinese (Cooke and Wei, 1988), Indians (Nanda and Nanda, 1969), Japanese (Miyajima *et al.*, 1996), Koreans (Hwang *et al.*, 2002), Mexican-Americans (Swlerenga *et al.*, 1994), Puerto Ricans (Evanko *et al.*, 1997), Saudi Arabians (Shalbhoub *et al.*, 1987), and Turks (Erbay *et al.*, 2002; Erbay and Caniklioğlu, 2002; Basciftci *et al.*, 2003, 2004). Many reasons exist for the inconsistencies between different studies (Arnett and Bergman, 1993a), including (1) different racial origins within the study populations; (2) some contained malocclusions, whereas others had normal bites or Class I occlusions only; (3) some were in the closed lip positions, whereas others were in relaxed lip position; (4) others used head films orientated to the cranial base structures, and others were in natural head position; (5) some values were from clinical measurement, although most were from the cephalometric radiographs; (6) the exact way of

measuring the same trait may be different from one study to the next; and (7) some contained patients who had not completed growth.

It can be concluded from a review of the literature that there are differences in the norms of dentofacial relationships of various ethnic and racial groups (Nanda and Nanda, 1969; Jacobson, 1978; Richardson, 1980; Shalbhoub *et al.*, 1987; Cooke and Wei, 1988; Kapila, 1989; Cerci *et al.*, 1993; Swlerenga *et al.*, 1994; Miyajima *et al.*, 1996; Evanko *et al.*, 1997; Erbay *et al.*, 2002; Erbay and Caniklioğlu, 2002; Hwang *et al.*, 2002; Basciftci *et al.*, 2003, 2004). Therefore, it is important to develop norms of various populations with a standard method.

Turkey is situated in a unique location where populations from different regions have mixed with each other and have created a rich gene pool. The Turkish population has genes from Asiatic Turks, the Balkans, Caucasus, Middle East, Iran as well as from ancient Romans, Byzantines, and Arabs. Contemporary Turks are a mixture of these extant and extinct people and ideal to consider as a representative study population. Only a few studies have determined the soft tissue cephalometric data of the Anatolian Turkish population.

Erbay *et al.* (2002) cephalometrically investigated the horizontal lip position of Anatolian Turkish adults using the soft tissue analyses of Steiner, Ricketts, Burstone, Sushner, and Holdaway. In another study, Erbay and Caniklioğlu (2002) evaluated the soft tissue profile to determine orthodontists' perceptions of Anatolian Turkish adults' beauty. Basciftci *et al.* (2003) found that except for the measurements of soft tissue chin thickness and basic upper lip thickness, all soft tissue measurements were similar to Holdaway's norms.

There are no extensive and standardized published data to establish useful soft tissue cephalometric values for diagnosis and surgical treatment planning of Anatolian Turkish adults with dentofacial deformity. The aims of the present study were (1) to determine norms for Arnett *et al.* (1999) STCA from lateral cephalograms of Anatolian Turkish young adults and (2) to identify possible gender differences between males and females.

Materials and methods

The material comprised the lateral cephalometric radiographs of 350 individuals, 165 males and 185 females, selected from the archives of the Department of Orthodontics, Faculty of Dentistry, Erciyes University. The following criteria were used for selection of the sample:

1. Angle Class I occlusal relationship with normal overbite and overjet
2. Well-aligned upper and lower dental arches
3. Normal growth and development pattern
4. No history of previous orthodontic or prosthodontic treatment.

The lateral cephalometric radiograph of each subject was taken using a Orthopantomography® (OP100; Instrumentarium, Tuusula, Finland). After analysing the lateral cephalometric radiographs, 133 subjects (67 males, mean age 22.6 ± 2.2 years, and 66 females, mean age 22.1 ± 2.6 years) with normal antero-posterior (ANB angle, 2 ± 2 degrees, mean 2.05 ± 1.11 degrees) and vertical (SN–MP angle, 32 ± 5 degrees, mean 32.84 ± 1.10 degrees) skeletal relationships were selected (Riedel, 1952; Erbay *et al.*, 2002; Erbay and Caniklioğlu, 2002).

The hard and soft tissue landmarks were digitized and the measurements were carried out using Dolphin Image Software, Version 9.0 (Dolphin Imaging and Management Solutions, Los Angeles, California, USA). Twenty hard and 38 soft tissue measurements were used to evaluate the soft tissue profile (Figure 1).

All radiographs had been obtained with metallic markers placed on the right side of the face to mark key midface structures according to the description of Arnett *et al.* (1999).

With the midface structures marked, a lateral cephalogram was obtained according to the standardized method of Arnett

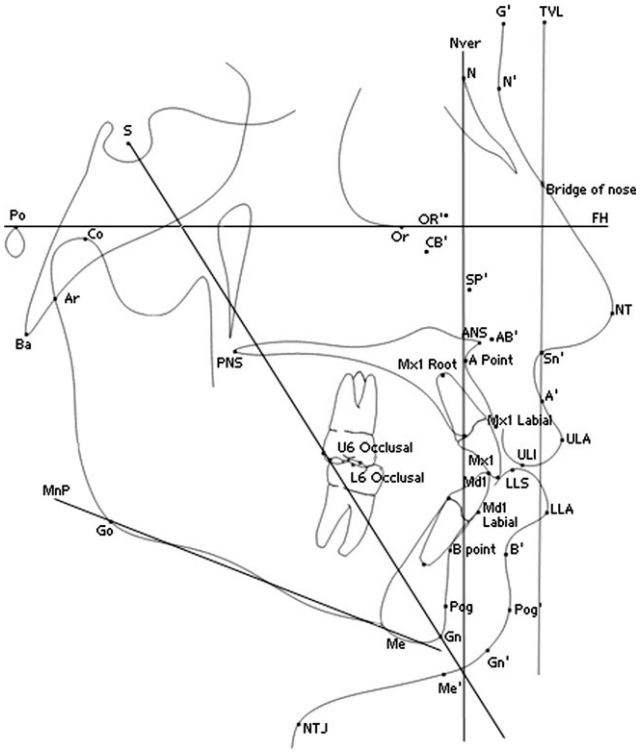

Figure 1 Reference points and planes: TVL, true vertical line; G', soft tissue glabella; N', soft tissue nasion; NT, tip of nose; Sn', subnasale; ULA, upper lip; LLA, lower lip; ULI, stomion superius; LLS, stomion inferius; B', soft tissue B point; Pog', soft tissue pogonion; Gn', soft tissue gnathion; Me', soft tissue menton; NTJ, throat point; N, Nasion, OR', orbital rim; Or, orbitale; CB', cheek bone; SP', subpupil; AB', alar base; ANS, anterior nasal spine; PNS, posterior nasal spine; Mx1, U1 tip; Md1, L1 tip; Pog, pogonion; Gn, gnathion; Me, menton; Go, gonion; Ba, basion; Ar, articulare; Co, condylion; Po, portion; S, sella; Nver, nasion vertical; FH, Frankfort horizontal; Mn P, mandibular plane; and PP, palatal plane.

et al. (1999). The true vertical line (TVL) was then established (Figure 1). The line was positioned through subnasale and was perpendicular to the natural horizontal head position (Spradley *et al.*, 1981). Soft tissue landmarks were then marked on the cephalogram. The midface metallic landmarks were also identified as new landmarks on the head film. Hard tissue landmarks were then identified on the cephalogram. The vertical or horizontal position of the soft and hard tissue landmarks was then measured relative to the subject's natural horizontal head position or TVL (Arnett *et al.*, 1999).

Statistical method

All statistical analyses were performed using the Statistical Package for Social Sciences (Windows, version 13.0; SPSS Inc., Chicago, Illinois, USA). Arithmetic mean and standard deviation (SD) were calculated for each measurement.

To determine the errors associated with radiographic measurements, 25 radiographs were selected. Their tracings and measurements were repeated 3 weeks after the first measurement. A paired sample *t*-test was applied to the first and second measurements. It was found that the difference between the first and second measurements of the 25 radiographs was insignificant. Correlation analysis applied to the same measurements showed the highest *r* value, 0.995, for Mx1 projection to TVL and the lowest, 0.818, for overjet.

An independent-samples *t*-test was performed for statistical evaluation of gender dimorphism.

Results

Descriptive statistics of the dentoskeletal factors, soft tissue structures, facial lengths, and projections to TVL norms are shown in Table 1.

Table 2 shows the mean and SD of the measurements for both genders together with the norm values of STCA (Arnett *et al.* 1999). Statistical analysis demonstrated that males and females were facially similar for 15 of the 34 measurements. There were no significant differences for any dentoskeletal

Table 1 Turkish standards assessed according to soft tissue cephalometric analysis of Arnett *et al.* (1999).

	Minimum	Maximum	Mean	Standard deviation
Dentoskeletal				
Mx occlusal plane (°)	88.70	108.40	98.60	4.41
Mx1 to Mx occlusal plane (°)	49.20	71.50	58.40	4.67
Md1 to Md occlusal plane (°)	53.90	84.70	65.99	6.49
Overjet (mm)	2.20	4.00	2.85	0.89
Overbite (mm)	2.10	4.10	2.43	0.62
Soft tissue structure				
Upper lip thickness (mm)	7.20	18.50	13.58	2.24
Lower lip thickness (mm)	6.20	15.40	10.77	1.75
Pogonion–pogonion' (mm)	7.80	20.50	12.95	2.33
Menton–Menton' (mm)	6.80	20.40	11.14	2.75
Nasolabial angle (°)	83.30	137.40	106.95	9.53
Upper lip angle (°)	−4.30	19.20	10.25	7.95
Facial length				
Nasion'–Menton' (mm)	112.90	150.70	130.21	8.08
Upper lip length (mm)	13.70	31.80	21.88	3.29
Interlabial gap (mm)	0.00	8.20	1.30	1.43
Lower lip length (mm)	38.60	60.20	49.39	4.26
Lower facial third (mm)	57.00	89.50	72.54	6.33
Overbite (mm)	1.10	4.10	2.23	0.62
Mx1 exposure (mm)	−1.90	9.80	2.73	2.01
Maxillary height (mm)	17.20	32.40	2.46	3.14
Mandibular height (mm)	41.40	62.80	50.16	4.29
Projections to true vertical line				
Glabella (mm)	−8.50	−5.90	−8.39	0.39
Orbital rims (mm)	−37.50	−17.80	−26.75	3.30
Cheek bone (mm)	−41.80	−21.70	−31.17	3.62
Subpupil (mm)	−28.40	−10.80	−19.96	3.59
Alar base (mm)	9.90	23.20	16.76	2.32
Nasal projection (mm)	−19.30	−6.60	−13.15	2.46
Subnasale (mm)	0.00	0.00	0.00	0.00
Point A' (mm)	−5.60	1.90	−1.78	1.48
Upper lip anterior (mm)	−5.50	8.60	1.55	2.41
Mx1 (mm)	−21.50	−1.90	−13.11	3.66
Md1 (mm)	−24.40	−4.70	−15.96	3.61
Lower lip anterior (mm)	−8.20	9.30	−11.25	3.28
Point B' (mm)	−22.50	4.00	−9.79	4.24
Pogonion' (mm)	−20.80	8.70	−6.42	5.32

Table 2 Gender differences in the Turkish sample and standard values of Arnett *et al.* (1999) for soft tissue cephalometric analysis.

	Arnett *et al.* (1999), females, mean ± SD	Turkish sample, females, mean ± SD	Arnett *et al.* (1999), males, mean ± SD	Turkish sample, males, mean ± SD	Turkish sample, female to male difference
Dentoskeletal					
Mx occlusal plane (°)	95.6 ± 1.8	99.1 ± 4.3	95.0 ± 1.4	98.1 ± 4.5	NS
Mx1 to Mx occlusal plane (°)	56.8 ± 2.5	58.0 ± 4.5	57.8 ± 3.0	58.8 ± 4.9	NS
Md1 to Md occlusal plane (°)	64.3 ± 3.2	65.3 ± 6.4	64.0 ± 4.0	66.7 ± 6.6	NS
Overjet (mm)	3.2 ± 0.4	2.9 ± 0.8	3.2 ± 0.6	2.8 ± 1.0	NS
Overbite (mm)	3.2 ± 0.7	2.5 ± 1.6	3.2 ± 0.7	2.4 ± 1.6	NS
Soft tissue structure					
Upper lip thickness (mm)	12.6 ± 1.8	12.4 ± 1.8	14.8 ± 1.4	14.7 ± 2.1	***
Lower lip thickness (mm)	13.6 ± 1.4	10.2 ± 1.6	15.1 ± 1.2	11.3 ± 1.7	***
Pogonion–pogonion' (mm)	11.8 ± 1.5	12.0 ± 2.0	13.5 ± 2.3	13.9 ± 2.3	***
Menton–Menton' (mm)	7.4 ± 1.6	10.2 ± 2.2	8.8 ± 1.3	12.2 ± 2.9	***
Nasolabial angle (°)	103.5 ± 6.8	108.1 ± 8.3	106.4 ± 7.7	106.8 ± 10.6	NS
Upper lip angle (°)	12.1 ± 5.1	12.0 ± 7.1	8.3 ± 5.4	8.7 ± 6.4	NS
Facial length					
Nasion'–Menton' (mm)	124.6 ± 4.7	124.9 ± 5.8	137.7 ± 6.5	135.7 ± 6.3	***
Upper lip length (mm)	21.0 ± 1.9	20.4 ± 2.9	24.4 ± 2.5	23.4 ± 3.0	***
Interlabial gap (mm)	3.3 ± 1.3	1.4 ± 1.3	2.4 ± 1.1	1.2 ± 1.6	NS
Lower lip length (mm)	46.9 ± 2.3	46.9 ± 3.1	54.3 ± 2.4	52.0 ± 3.7	***
Lower facial third (mm)	71.1 ± 3.5	68.7 ± 4.5	81.1 ± 4.7	76.5 ± 5.5	***
Overbite (mm)	3.2 ± 0.7	2.5 ± 1.6	3.2 ± 0.7	2.4 ± 1.6	NS
Mx1 exposure (mm)	4.7 ± 1.6	3.3 ± 1.7	3.9 ± 1.2	2.1 ± 2.1	***
Maxillary height (mm)	25.7 ± 2.1	23.7 ± 2.8	28.4 ± 3.2	25.5 ± 3.2	**
Mandibular height (mm)	48.6 ± 2.4	47.4 ± 2.9	56.0 ± 3.0	52.9 ± 3.7	***
Projections to true vertical line					
Glabella (mm)	−8.5 ± 2.4	−8.4 ± 0.3	−8.0 ± 2.5	−8.4 ± 0.5	NS
Orbital rims (mm)	−18.7 ± 2.0	−24.8 ± 2.1	−22.4 ± 2.7	−28.7 ± 3.1	***
Cheek bone (mm)	−20.6 ± 2.4	−29 ± 2.3	−25.2 ± 4.0	−33.4 ± 3.3	***
Subpupil (mm)	−14.8 ± 2.1	−17.9 ± 2.7	−18.4.0 ± 1.9	−22.1 ± 3.2	***
Alar base (mm)	−12.9 ± 1.1	−11.9 ± 1.9	−15.0 ± 1.7	−14.5 ± 2.3	**
Nasal projection (mm)	16.0 ± 1.4	16.1 ± 1.8	17.4 ± 1.7	17.4 ± 2.6	***
Subnasale (mm)	0	0.0	0	0.0	NS
Point A' (mm)	−0.1 ± 1.0	−0.2 ± 1.2	−0.3 ± 1.0	−0.2 ± 1.8	NS
Upper lip anterior (mm)	3.7 ± 1.2	1.2 ± 1.9	3.3 ± 1.7	1.9 ± 2.8	NS
Mx1 (mm)	−9.2 ± 2.2	−11.9 ± 2.9	−12.1 ± 1.8	−14.4 ± 4.0	***
Md1 (mm)	−12.4 ± 2.2	−14.8 ± 2.7	−15.4 ± 1.9	−17.1 ± 4.0	***
Lower lip anterior (mm)	1.9 ± 1.4	−1.2 ± 2.7	1.0 ± 2.2	−1.0 ± 3.8	NS
Point B' (mm)	−5.3 ± 1.5	−9.1 ± 3.7	−7.1 ± 1.6	−10.5 ± 4.7	NS
Pogonion' (mm)	−2.6 ± 1.9	−6.4 ± 5.0	−3.5 ± 1.8	−6.4 ± 5.6	NS

SD, standard deviation; NS: not significant; **$P < 0.01$; ***$P < 0.001$.

measurements in males or females. All soft tissue thicknesses were statistically greater in males (upper and lower lip thicknesses, Pog–Pog', and Me–Me') than in females. According to face height measurements, males showed statistically significantly greater values than females [Na'Me' ($P < 0.001$), upper and lower lip length ($P < 0.001$), lower facial third ($P < 0.001$), maxillary height ($P < 0.01$), and mandibular height ($P < 0.001$)]. Only Mx1 exposure was greater in females than in males (3.3 versus 2.1 mm; $P < 0.001$). Fifty per cent of the projection to TVL measurements was statistically significant between genders. The orbital rim ($P < 0.001$), cheek bone ($P < 0.001$), subpupil ($P < 0.001$), alar base ($P < 0.01$), and nasal projection ($P < 0.001$) measurements were larger in males than in females. The upper (2.5 mm) and lower (2.3 mm) incisors of males were situated more negative to TVL than in females ($P < 0.001$).

Combined facial harmony norms, descriptive statistical values of intramandibular relationships, interjaw relationships, orbit to jaw, and full facial balance measurements are shown in Table 3.

Gender differences are presented in Table 4 together with the normative values of Arnett *et al.* (1999) for males and females. Md1 to pogonion' ($P < 0.01$) and point B' to pogonion' ($P < 0.001$) were found to be statistically greater in males than in females. Among the interjaw harmony measurements, only point A'–point B' showed greater values in males ($P < 0.05$). All male orbit to jaw values were statistically greater (orbital rim'–A point' and

orbital rim'–pogonion'; $P < 0.001$). Full facial balance means were not statistically different between males and females.

Discussion

Clinical examination is important and provides information of both the sagittal and frontal views of the patients (Arnett and Gunson, 2004). It is, however, subjective. In daily practice, different methods are used to evaluate cephalometric radiographs. The advantage of such analyses is that they provide the ability to make objective evaluation of important structures and relationships (Arnett and Bergman, 1993a,b; Arnett and McLaughlin, 2004). Soft tissue cephalometric analysis is a method for quantifying facial disharmony and identifying its underlying cause. This is important because, as a rule, improved facial aesthetics are achieved if the underlying problems are identified and treated. Therefore, population-specific norms of soft tissue values should be used throughout treatment.

While measurement norms serve as guidelines in calculating change (Farkas and Kolar, 1987), they should be used only as a guide. Ideal treatment planning should affect the facial trait in a positive fashion, coming close to the standard (Arnett *et al.*, 1999).

Oliver (1982) stated that the instruction to 'bring the lips lightly closed' would allow the subject a tactile neuromuscular input to facilitate the positioning of the lips in a repeatable manner. That author considered that emotional and neuromuscular inputs into lip posture make it difficult to capture a relaxed lip posture repeatedly. However, for soft tissue evaluation, Arnett and Gunson (2004) suggested that the patient should be positioned in a relaxed lip position as relaxed lips demonstrate the relationship of soft tissues relative to hard tissues without muscular compensation for dentoskeletal abnormalities. In the present study for standardization of the method, the relaxed lip position was also used when taking the cephalograms for accurate assessment of the soft tissues.

Table 3 Turkish standards of facial harmony.

Relationship	Minimum	Maximum	Mean	Standard deviation
Intramandibular				
Md1–pogonion' (Pog')	−0.90	22.40	9.54	4.35
Lower lip anterior–Pog'	−7.10	13.20	5.29	3.50
Point B'–Pog'	−1.10	10.00	3.37	2.29
Throat length (neck throat point to Pog')	22.80	85.80	56.10	9.13
Interjaw				
Subnasale'–Pog'	−8.70	20.80	6.42	5.32
Point A'–point B'	−2.70	17.30	8.01	3.65
Upper lip anterior–lower lip anterior	−1.70	6.50	2.68	1.79
Orbit to jaw				
Orbital rim'–point A'	14.60	37.10	24.96	3.59
Orbital rim'–Pog'	6.20	35.70	20.33	6.24
Full facial balance				
Facial angle	153.40	181.70	167.00	5.18
Glabella'–point A'	2.10	10.00	6.60	1.55
Glabella'–Pog'	−12.30	17.20	1.97	5.37

Table 4 Gender differences in the Turkish sample and norm values of Arnett *et al.* (1999) for facial harmony.

Relationship	Arnett *et al.* (1999), females, mean ± SD	Turkish sample, females, mean ± SD	Arnett *et al.* (1999), males, mean ± SD	Turkish sample, males, mean ± SD	Turkish sample, female to male difference
Intramandibular					
Md1–Pog' (mm)		8.4 ± 4.0	11.9 ± 2.8	10.7 ± 4.3	**
Lower lip anterior–Pog' (mm)	4.5 ± 2.1	5.2 ± 3.4	4.4 ± 2.5	5.3 ± 3.5	NS
B point'–Pog' (mm)	2.7 ± 1.1	2.7 ± 2.1	3.6 ± 1.3	4.0 ± 2.2	***
Throat length (neck throat point to Pog') (mm)	58.2 ± 5.9	56.5 ± 7.6	61.4 ± 7.4	55.6 ± 8.5	NS
Interjaw					
Subnasale'–Pog' (mm)	3.2 ± 1.9	6.4 ± 5.0	4.0 ± 1.7	6.4 ± 5.6	NS
Point A'–point B' (mm)	5.2 ± 1.6	7.2 ± 3.3	6.8 ± 1.5	8.8 ± 3.8	*
Upper lip anterior–lower lip anterior (mm)	1.8 ± 1.0	2.4 ± 1.6	2.3 ± 1.2	2.9 ± 1.8	NS
Orbit to jaw					
Orbital rim'–point A' (mm)	18.5 ± 2.3	22.9 ± 2.4	22.1 ± 3 8	27.0 ± 3.3	***
Orbital rim'–Pog' (mm)	16.0 ± 2.6	18.4 ± 5.5	18.9 ± 2.8	22.3 ± 6.3	***
Full facial balance					
Facial angle (°)	169.3 ± 3.4	166.6 ± 5.0	169.4 ± 3.2	167.4 ± 5.3	NS
Glabella'–point A' (mm)	8.4 ± 2.7	6.5 ± 1.1	7.8 ± 2.8	6.7 ± 1.8	NS
Glabella'–Pog' (mm)	5.9 ± 2.3	1.9 ± 5.1	4.6 ± 2.2	1.9 ± 5.6	NS

SD, standard deviation; NS: not significant; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

The orthodontist and surgeon greatly influence the resulting profile of the patient by managing the dentoskeletal components. Dentoskeletal factors have a large influence on the facial profile. These factors, when within normal range, will usually produce a balanced and harmonious nasal base, lip, soft A', soft B', and chin relationship (Arnett *et al.*, 1999). All dentoskeletal factor norms, except overbite and overjet values of this Turkish sample were similar to the norms of Arnett *et al.* (1999). No gender differences for any of the dentoskeletal components of the STCA were found, consistent with their findings.

Soft tissue structures (thickness of upper lip, lower lip, B to B', Pog to Pog', Me to Me', nasolabial angle, and upper lip angle) are important for facial aesthetics (Arnett *et al.*, 1999). These soft tissue components are altered by movement of the incisors and change the facial profile. Lower lip thickness of the Turkish population was less and chin thickness was greater than the norm values of Arnett *et al.* (1999). According to Basciftci *et al.* (2003), the norm for soft tissue chin thickness in the Turkish population was found to be greater than that in American norms. In the present study, statistically significant gender differences were determined for the thickness of upper and lower lip and Pog and Me measurements. All male soft tissue thicknesses were statistically greater than those of females. The nasolabial angle is useful in evaluating the antero-posterior position of the maxilla (Bergman, 1999) and with the upper lip angle, they reflect the position of the upper incisor teeth and the thickness of the soft tissue overlying these teeth (Arnett *et al.*, 1999). Legan and Burstone (1980) indicated that in surgical procedures this angle should be in the range of 102 ± 8 degrees. The nasolabial angle remains relatively constant in growing individuals between the ages of 7 and 17 years (Bergman, 1999). Turkish adult norms were near the upper border of the range and showed no gender differences. Upper lip angle showed values similar to the standards of Arnett *et al.* (1999).

Upper and lower lip length, interlabial gap, lower facial third, and total face height are parts of soft tissue facial lengths. Additional essential vertical measurements include relaxed lip upper incisor exposure, maxillary height (Sn to Mx1 tip), mandibular height (Md1 tip to Me'), and overbite. The presence and location of vertical abnormalities is indicated by assessing maxillary height, mandibular height, upper incisor exposure, and overbite (Arnett *et al.*, 1999). For facial length measurements, nearly all determined means of Turkish values were within the range of the standards of Arnett *et al.* (1999). Most of the soft tissue vertical measurements in this study showed statistically significant gender differences, with the facial lengths of males being longer than those of females except for upper incisor exposure.

Projections to TVL are antero-posterior measurements of the soft tissues and represent the sum of the dentoskeletal position plus the soft tissue thickness overlying that hard tissue landmark (Arnett *et al.*, 1999). TVL position is based on where subnasale appears on the cephalometric film (Legan and Burstone, 1980). When the Turkish standards for TVL projections were compared with the norms of Arnett *et al.* (1999), it was observed that Turkish subjects have depressed orbital rims, cheek bones, subpupils, upright and thin upper and lower lips, retruded incisors, and pogonion and points B. Statistically significant gender differences were found for 50 per cent of the projections to TVL measurements. Turkish males have more retruded soft tissue structures to TVL for orbital rim, cheek bone, subpupil, alar base, and Mx1 and Md1 measurements. Only nasal projection to TVL was found to be greater in males than in females.

The harmony values were obtained to measure the balance and harmony of facial structures (Arnett *et al.*, 1999). Harmony is the position of each landmark relative to other landmarks that determines facial balance. These values represent the horizontal distance between two landmarks measured perpendicular to the TVL. Harmony numbers provide a test of facial balance within the individual's face and, importantly, are independent of the true vertical antero-posterior placement (Arnett *et al.*, 1999). These measurements basically examine four areas: intramandibular and interjaw relations, orbits to jaws, and the total face.

Intramandibular harmony is the first step of the harmony examination. These values assess chin projection relative to the lower incisor, lower lip, soft tissue B' point, and the neck throat point. Evaluation of these relationships indicates chin position relative to other mandibular structures and which, if any, structure is abnormally placed (Arnett *et al.*, 1999). It was determined that the norm values for Md1, LLA, B', and neck throat point to chin were 9.54 ± 4.35, 5.29 ± 3.50, 3.37 ± 2.29, and 56.10 ± 9.13 mm, respectively. In diagnosis and surgical planning, these norm values can be used by the clinician. For example, a patient with the throat length under the norm values (sagging/short throat length) is not a good candidate for mandibular setback, and long throat length indicates mandibular protrusion and is an indication for a mandibular setback (Lundström and Lundström, 1992).

Interjaw harmony relationships directly control the lower one-third of facial aesthetics (Arnett *et al.*, 1999). Values indicate the interrelationship between the base of the maxilla (Sn) to chin (Pog'), soft tissue B' to soft tissue A', and upper to lower lips. Turkish interjaw harmony norm values (Sn–Pog': 6.42 ± 5.32, A'–B': 8.01 ± 3.65, and ULA–LLA: 2.68 ± 1.79) were obtained. Except Sn–Pog' measurement, other values were similar to the findings of Arnett *et al.* (1999). However, Sn–Pog' measurement showed higher SDs. Only male subjects in the present study showed a statistically significant higher horizontal

distance than females between points A' and B' measured perpendicular to the TVL.

The orbital rim is an antero-posterior indicator of maxillary position (Arnett and Bergman, 1993b). Deficient orbital rims may correlate positionally with a retruded maxilla because the osseous structures are often deficient as groups, rather than in isolation (Arnett and Bergman, 1993b). According to orbital rim to jaw harmony, the position of the soft tissue inferior orbital rim relative to the upper (OR'–A') and lower (OR'–Pog') jaw was investigated. Deficient orbital rims according to norms dictate maxillary advancement when all the other factors are equal. Measurements between these areas assess high midface to jaw balance (Arnett *et al.*, 1999). Distinct differences were found between Turkish and Caucasian subjects (Arnett *et al.*, 1999) for orbital rim parameters. Turkish values were higher than the norms both for females (OR'–A': 22.9/18.5; OR'–Pog': 18.4/16.0) and for males (OR'–A': 27.0/22.1; OR'–Pog': 22.3/18.9). In the current study, it was found that males had a statistically different harmony for orbital rim' to A' and orbital rim' to Pog'.

The last part of the facial harmony evaluation assesses the upper face, midface, and chin which are related via the facial angle (G'–Sn–Pog'). The forehead is compared to two specific points, the upper jaw (G'–A') and chin (G'–Pog'). Arnett *et al.* (1999) indicated that these three measurements give the broad picture of facial balance. It was determined that the standard value for facial angle, glabella'–A point', and glabella'–pogonion' is 167.00 ± 5.18, 6.60 ± 1.55, and 1.97 ± 5.37 mm, respectively. All full facial harmony measurements showed no significant gender dimorphism.

Conclusion

According to facial length measurements, nearly all determined means of Turkish values were within the range of the standards of Arnett *et al.* (1999). Turkish subjects have depressed orbital rims, cheek bones, subpupils, upright and thin upper and lower lips, and retruded incisors, pogonion and point B.

Evaluation of the facial harmony values indicated that most Turkish mean harmony values for intramandibular and interjaw relationships, orbits to jaws, and the total face were within the range of harmony standards of Arnett *et al.* (1999).

All soft tissue thicknesses of Turkish males were statistically greater than those of females. Turkish males have more retruded soft tissue structures to TVL for orbital rim, cheek bone, subpupil, alar base, and Mx1 and Md1 measurements. Only nasal projection to TVL measurement was found to be greater in males than in females. Male subjects had statistically different dimensions for orbital rim' to A' and orbital rim' to Pog' points.

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References

Arnett G W, Bergman R T 1993a Facial keys to orthodontic diagnosis and treatment planning—part I. American Journal of Orthodontics and Dentofacial Orthopedics 103: 299–312

Arnett G W, Bergman R T 1993b Facial keys to orthodontic diagnosis and treatment planning—part II. American Journal of Orthodontics and Dentofacial Orthopedics 103: 395–411

Arnett G W, Gunson J G 2004 Facial planning for orthodontists and oral surgeons. American Journal of Orthodontics and Dentofacial Orthopedics 126: 290–295

Arnett G W, McLaughlin R P 2004 Facial and dental planning for orthodontists and oral surgeons. Mosby, London

Arnett G W *et al.* 1999 Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. American Journal of Orthodontics and Dentofacial Orthopedics 116: 239–253

Basciftci F A, Uysal T, Büyükerkmen A 2003 Determination of Holdaway soft tissue norms in Anatolian Turkish adults. American Journal of Orthodontics and Dentofacial Orthopedics 123: 395–400

Basciftci F A, Uysal T, Büyükerkmen A 2004 Craniofacial structure of Anatolian Turkish adults with normal occlusions and well-balanced faces. American Journal of Orthodontics and Dentofacial Orthopedics 125: 366–372

Bergman R T 1999 Cephalometric soft tissue facial analysis. American Journal of Orthodontics and Dentofacial Orthopedics 116: 373–389

Broadbent B H 1931 A new X-ray technique and its application to orthodontia. Angle Orthodontist 1: 45–66

Burstone C J 1958 The integumental profile. American Journal of Orthodontics 44: 1–25

Burstone C J 1967 Lip posture and its significance in treatment planning. American Journal of Orthodontics 53: 262–284

Cerci V, Martins J E, de Olivera M A 1993 Cephalometric standards for white Brazilians. International Journal of Adult Orthodontics and Orthognathic Surgery 8: 287–292

Cooke M S, Wei S H Y 1988 Cephalometric 'standards' for the southern Chinese. European Journal of Orthodontics 10: 264–272

Erbay E F, Caniklioğlu C M 2002 Soft tissue profile in Anatolian Turkish adults: part II. Comparison of different soft tissue analyses in the evaluation of beauty. American Journal of Orthodontics and Dentofacial Orthopedics 121: 65–72

Erbay E F, Caniklioğlu C M, Erbay S K 2002 Soft tissue profile in Anatolian Turkish adults: part I. Evaluation of horizontal lip position using different soft tissue analyses. American Journal of Orthodontics and Dentofacial Orthopedics 121: 57–64

Evanko A M, Freeman K, Cisneros G J 1997 Mesh diagram analysis: developing a norm for Puerto Rican Americans. Angle Orthodontist 67: 381–388

Farkas L G, Kolar J C 1987 Anthropometrics and art in the aesthetics of women's faces. Clinical Plastic Surgery 14: 599–615

Holdaway R A 1984 A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part II. American Journal of Orthodontics 85: 279–293

Hwang H S, Kim W S, McNamara J A 2002 Ethnic differences in the soft tissue profile of Korean and European-American adults with normal occlusion and well-balanced faces. Angle Orthodontist 72: 72–80

Jacobson A 1978 The craniofacial pattern of the South African Negro. American Journal of Orthodontics 73: 682–692

Kapila S 1989 Selected cephalometric angular norms in Kikuyu children. Angle Orthodontist 59: 139–144

Legan H L, Burstone C J 1980 Soft tissue cephalometric analysis for orthognathic surgery. Journal of Oral Surgery 38: 744–751

Lundström A, Lundström F 1992 Natural head position as a basis for cephalometric analysis. American Journal of Orthodontics and Dentofacial Orthopedics 101: 244–247

Miyajima K, McNamara J A, Kimura T, Murata S, Iizuka T 1996 Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. American Journal of Orthodontics and Dentofacial Orthopedics 110: 431–438

Nanda R, Nanda R S 1969 Cephalometric study of the dentofacial complex of North Indians. Angle Orthodontist 39: 22–28

Oliver B M 1982 The influence of lip thickness and strain on upper lip response to incisor retraction. American Journal of Orthodontics 82: 141–149

Richardson R E 1980 Racial differences in dimensional traits of the human face. The Angle Orthodontist 50: 301–311

Ricketts R M, Roth R H, Chaconos S J, Schulhof R J, Engle G A 1982 Orthodontic diagnosis planning. Rocky Mountain Orthodontics, Denver

Riedel R A 1957 An analysis of dentofacial relationships. American Journal of Orthodontics 43: 103–119

Riedel R R 1952 The relation of maxillary structures to cranium in malocclusion and in normal occlusion. Angle Orthodontist 22: 142–145

Shalbhoub S Y, Sahran O A, Shaikh H S 1987 Adult cephalometric norms for Saudi Arabians with a comparison of values for Saudi and North American Caucasians. British Journal of Orthodontics 14: 273–279

Spradley F L, Jacobs J, Crowe D P 1981 Assessment of the anteroposterior soft tissue contour of the lower facial third in the ideal young adult. American Journal of Orthodontics 79: 316–325

Steiner C C 1959 Cephalometrics in clinical practice. Angle Orthodontist 29: 8–29

Swlerenga D, Oesterle L J, Messersmith M L 1994 Cephalometric values for adult Mexican-Americans. American Journal of Orthodontics and Dentofacial Orthopedics 106: 146–155

Tweed C H 1944 Indications for extraction of teeth in orthodontic procedure. American Journal of Orthodontics and Oral Surgery 30: 405–428