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Longitudinal profile changes in an Anatolian Turkish population

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SUMMARY The goal of this study was to assess longitudinal changes in the facial soft tissue profile in relation to age and gender in young Anatolian Turkish subjects.

A total of 30 subjects (15 females and 15 males) with an Angle Class I occlusal relationship and normal antero-posterior (ANB, 2–4 degrees) skeletal relationships were selected from the archive of Dicle University. All subjects were of Anatolian Turkish heritage, and none had any apparent facial disharmony or had undergone orthodontic therapy. Lateral cephalometric radiographs taken at T1 (mean age 8.8 years), T2 (mean age 13.8 years), and T3 (mean age 17.8 years) were separately investigated. Non-gender-specific research was also carried out at the same time periods. In total, 24 measurements were analysed longitudinally. Differences between the genders were determined using independent *t*-tests. Repeated measures analysis of variance tests were used to evaluate repeated measurements, and paired sample *t*-tests to compare inside effects between the genders.

Significant increases ($P < 0.05$) were found with age for both females and males. Generally, the increases were greater in males than in females. Nasal prominence increased more than chin prominence, resulting in a tendency to have convex profiles.

Introduction

In today's multicultural society, racial and ethnic differences have become increasingly important within the medical field. In the past, the majority of patients in a given practice were usually from one or two racial or ethnic groups (e.g. Japanese in Tokyo, European-Americans, and African-Americans in Chicago). Metropolitan areas now have a far more diverse patient population, and it is important to realize that a single standard of facial aesthetics may not be appropriate when making diagnostic and treatment planning decisions about patients from diverse racial and ethnic backgrounds (Miyajima *et al.*, 1996). Awareness of normal dentofacial patterns for various ethnic groups will undoubtedly ensure greater success in orthodontic treatment.

Several normative data studies have been conducted in various parts of the world and are now used as reference material in orthodontic research. These include the Michigan (Riolo *et al.*, 1974), Bolton (Broadbent *et al.*, 1975), Nijmegen (Prahl-Andersen *et al.*, 1979), and King's (Bhatia and Leighton, 1993) Growth Studies. Growth studies have also been collected in university projects to develop standards for specific ethnic groups (Alexander and Hitchcock, 1978; Munandar and Snow, 1995). Several investigators have demonstrated that ethnic groups vary in their dentofacial configurations (Johnson *et al.*, 1978; Björk *et al.*, 1984).

Harmonious facial aesthetics and functional occlusion have long been recognized as two of the goals of orthodontic treatment. Knowledge concerning normal craniofacial growth is essential to accomplish these goals (Bishara *et al.*, 1985; Thilander *et al.*, 2005). The importance of soft tissue and facial aesthetics in orthodontic treatment was emphasized by Angle (1907). That author believed that facial harmony and balance depended largely on the form and beauty of the mouth. Although the ideal of beauty has changed over the centuries and differs between populations, it has always been a subject of interest and importance to people of all cultures (Hambleton, 1964), and many researchers have studied facial aesthetics (Ricketts, 1968; Arnett and Bergman, 1993a,b).

It has been demonstrated that linear and angular cephalometric measurements of the face and cranial base differ between males and females and also change with age (Riolo *et al.*, 1974; Broadbent *et al.*, 1975; Thilander *et al.*, 2005).

Soft tissue cephalometric standards for various ethic groups by gender and age are important for orthodontic diagnosis, treatment planning, and evaluation of treatment. Few longitudinal studies of cephalometric soft tissue variables have been published concerning the Turkish population. Turkey is a country located between Asia and Europe and has a population of approximately 70 million. The purpose of the present study was to establish age- and gender-specific normative soft tissue data for a Turkish population aged 8.8–17.8 years.

Subjects and methods

The sample population included 30 untreated subjects from the records of the Dicle University archive. All 30 individuals (15 males and 15 females) presented a dental and skeletal Class I sagittal (ANB, 2–4 degrees) and normal vertical pattern. None had a history of orthodontic treatment, airway problems, or any previous craniofacial trauma, surgery, or congenital anomalies. All had normal dentofacial dimensions and proportions, as well as a normal occlusion, overjet, and overbite, and no crowding. The serial records included lateral cephalograms and clinical recordings taken at the chronological ages of 8.8 (T1), 13.8 (T2), and 17.8 (T3). Table 1 presents the mean ages for females, males, and the total group.

The lateral cephalometric radiograph of each subject was taken with an Asahi Cephalometer (CX 90X, Asahi Roentgen, Kyoto, Japan) at the Dental Radiology Clinic of Dicle University School of Dentistry. All subjects were positioned in the cephalostat with the sagittal plane at right angle to the path of the X-rays, the Frankfort plane parallel to the horizontal, the teeth in centric occlusion, and the lips lightly closed (Erbay *et al.*, 2002).

A single author (NH) traced all the radiographs by hand on 0.003 matte acetate sheets. SNA, SNB, and ANB angles for all subjects were measured to confirm an Angle Class I malocclusion. Seventeen linear and four angular measurements were also determined to assess soft tissue growth.

The individuals in the study were classified by gender at each time period and then combined. Linear and angular soft tissue measurements were conducted according to the points and lines shown in Figures 1 and 2. Figures 3 and 4 demonstrate the linear measurements, and Figure 5 the angular measurements. Gender differences and time-related changes over different periods were statistically assessed.

Statistical analysis

Differences between genders were determined using an independent *t*-test. A repeated measures analysis of variance was used to evaluate repeated measurements and a paired sample *t*-test to compare between-group effects. Normal distributions were evaluated using the Kolmogorov–Smirnov test, and homogeneity with Levene's test (Windows, release 15.0 SPSS, Chicago, Illinois, USA).

Error of the method

One month after the first measurement, the lateral cephalometric radiographs of 15 patients were randomly selected and re-measured by the same examiner. The casual error was calculated according to the formula ($S^2 = \Sigma d^2/2n$) (Dahlberg, 1940), where S^2 is the error of variance and d is the difference between the two determinations of the same variable. Systematic error was evaluated with dependent *t*-tests, with the level of significance set at $P < 0.05$.

Results

The results of the systematic and casual errors are presented in Table 2. No systematic errors were detected, and the casual errors were within acceptable levels.

Differences between groups were tested using an independent *t*-test. The results indicated statistically significant differences in ANS/Me, ST nasion/subnasale, subnasale/stomion, SD/UL, LT/LL, and nasolabial angle measurements at T1; N/Me, ANS/Me, subnasale/stomion, and LI/LL measurements at T2; and ANB, N/me, ANS/me, ST nasion/subnasale, subnasale/stomion, stomion/ST Me, ANS/SLS, SD/UL, LI/LL, and nasal bone/SN measurements at T3 (Table 3).

Comparison of female subjects between T1 and T2 revealed statistically significant decreases in nasal dorsum/FH and nasolabial angle measurements and statistically significant increases in all measurements except ANB angle (Table 4). During the same time period, males demonstrated statistically significant decreases in ANB angle and nasal dorsum/FH measurements and statistically significant increases in all measurements except columella FH and nasolabial angle measurements (Table 5). In the total group, ANB angle, nasolabial dorsum/FH and nasolabial angle decreased significantly, whereas all other measurements increased significantly (Table 6).

Comparison of female subjects between T2 and T3 revealed statistically significant decreases in nasal dorsum/FH measurements and statistically significant increases in all parameters except for ANB and nasolabial angles (Table 4). During the same time period, males demonstrated

Table 1 Age range and standard deviations (SDs) of subjects at the mean ages of 8.8 (T1), 13.8 (T2), and 17.8 (T3) years.

Gender	T1 (X ± SD)	T2 (X ± SD)	T3 (X ± SD)
Male	8.61 ± 0.68	13.63 ± 0.54	17.63 ± 0.53
Female	9.11 ± 0.84	14.11 ± 0.71	18.13 ± 0.74
Total	8.80 ± 0.76	13.80 ± 0.62	17.81 ± 0.63

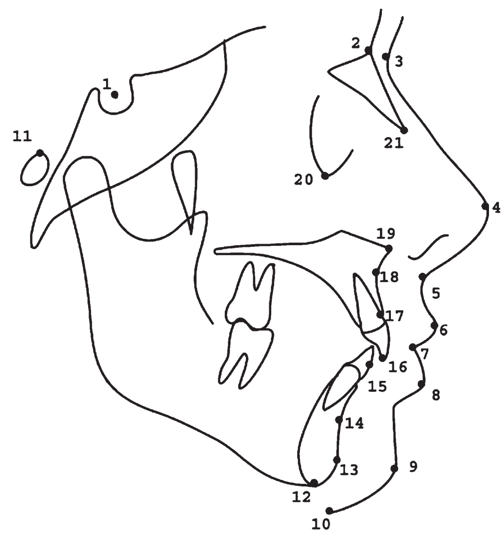

Figure 1 Hard and soft tissue landmarks used in cephalometric analysis. 1, sella (S); 2, nasion (N); 3, soft tissue (ST) nasion; 4, pronasale; 5, subnasale (SLS); 6, upper lip (UL); 7, stomion; 8, lower lip (LL); 9, Pgs (soft tissue pogonion); 10, soft tissue (ST) menton; 11, porion; 12, menton (Me); 13, pogonion (Pg); 14, point B; 15, upper central incisor (UI); 16, lower central incisor (LI); 17, SD (the contact point of maxillary bone with the upper central incisor); 18, point A; 19, anterior nasal spine (ANS); 20, orbitale; 21, rhinion (the anterior tip at the end of the suture of the nasal bones).

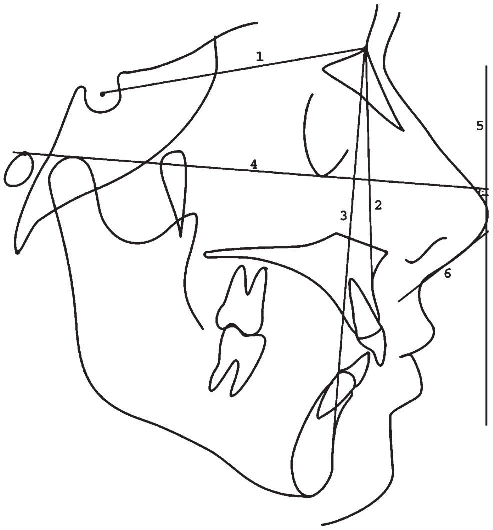

Figure 2 Cephalometric planes used in study. 1, SN: plane passing through sella and nasion; 2, NA: plane passing through nasion and point A; 3, NB: plane passing through nasion and point B; 4, Frankfort horizontal: plane passing through porion and orbitale; 5, nasal tip: line passing through pronasale perpendicular with the Frankfort horizontal plane; 6, columella.

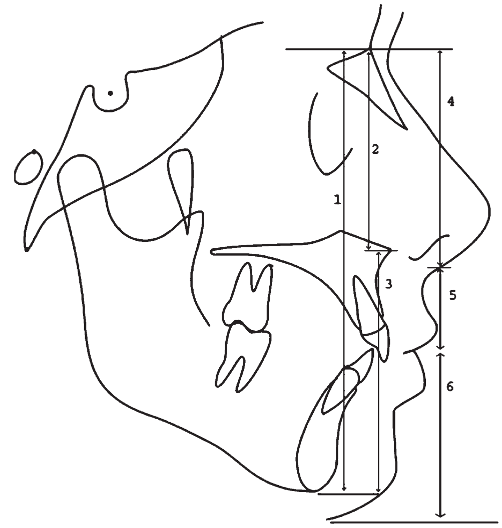

Figure 4 Vertical linear measurement. 1, N/Me; 2, N/ANS; 3, ANS/Me; 4, ST nasion/subnasale; 5, subnasale/stomion; 6, stomion/ST Me.

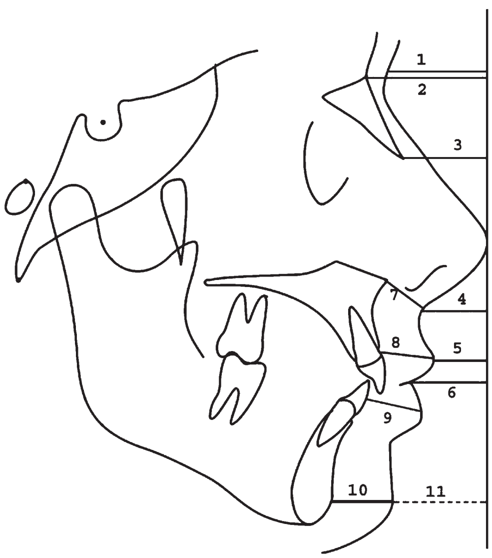

Figure 3 Antero-posterior linear measurements. 1, ST nasion/nasal tip; 2, nasion/nasal tip; 3, rhinion/nasal tip; 4, subnasale/nasal tip; 5, upper lip/nasal tip; 6, stomion/nasal tip; 7, ANS/SLS; 8, SD/UL; 9, LI/LL; 10, Pg/Pgs; 11, Pg/nasal tip.

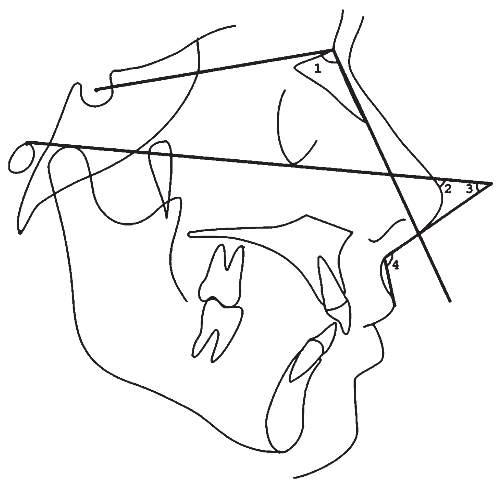

Figure 5 Angular measurements. 1, nasal bone/SN; 2, nasal dorsum/FH; 3, columella/FH; 4, nasolabial angle.

statistically significant decreases in ANB angle and nasal dorsum/FH measurements and statistically significant increases in all parameters except for nasolabial angle. In the total group, ANB angle and nasal dorsum/FH decreased significantly, whereas all other parameters increased statistically except nasolabial angle (Table 6).

Comparison of female subjects between T1 and T3 revealed statistically significant decreases in ANB angle, nasolabial dorsum/FH, and nasolabial angle and statistically significant increases in all other parameters (Table 4). During the same time period, males demonstrated statistically significant decreases in ANB angle and nasal dorsum/FH and statistically significant increases in all other parameters except columella/FH and nasolabial angle (Table 5). In the total group, ANB angle, nasal dorsum/FH, and nasolabial angle decreased significantly, whereas all other parameters increased significantly (Table 6).

Discussion

Orthodontists need to understand how soft tissues change during growth (Prahl-Andersen *et al.*, 1995). Predicted facial aesthetics can only be achieved if the amount and direction of growth can be correctly estimated (Nanda *et al.*, 1990).

Table 2 The results of the systematic and casual errors at the mean ages of 8.8 (T1), 13.8 (T2), and 17.8 (T3) years.

Parameter	*n*	T1		T2		T3	
		P value	Dahlberg value	*P* value	Dahlberg value	*P* value	Dahlberg value
SNA (°)	15	0.164	0.37	0.164	0.37	0.164	0.37
SNB (°)	15	0.189	0.55	0.082	0.55	0.164	0.37
ANB (°)	15	0.055	0.91	1.000	0.73	0.082	0.55
ST nasion/nasal tip (mm)	15	0.334	0.47	0.384	0.34	0.452	0.38
Nasion/nasal tip (mm)	15	0.271	0.91	0.104	0.73	0.433	0.73
Rhinion/nasal tip (mm)	15	0.271	0.91	0.271	0.91	0.486	0.82
Pg/nasal tip	15	0.513	0.61	0.614	0.49	0.345	0.51
Subnasale/nasal tip (mm)	15	0.670	0.91	0.271	0.91	0.719	0.91
Upper lip/nasal tip (mm)	15	0.189	0.91	0.715	0.83	0.334	0.73
Stomion/nasal tip (mm)	15	0.019	0.18	0.207	0.73	0.301	0.55
N/Me (mm)	15	0.582	0.55	0.582	0.91	0.271	0.73
N/ANS (mm)	15	0.719	0.91	0.334	0.91	0.582	0.55
ANS/Me (mm)	15	0.719	0.91	0.582	0.55	0.433	0.73
ST nasion/subnasale (mm)	15	0.164	0.37	0.164	0.37	0.433	0.73
Subnasale/stomion (mm)	15	0.433	0.55	0.582	0.91	0.582	0.73
Stomion/ST Me (mm)	15	0.582	0.55	0.670	0.91	0.164	0.37
ANS/SLS (mm)	15	0.041	0.73	0.751	0.91	0.189	0.91
SD/UL (mm)	15	0.719	0.91	0.433	0.73	0.164	0.37
LI/LL (mm)	15	0.189	0.55	0.582	1.10	0.582	0.55
Pg/Pgs (mm)	15	0.164	0.37	0.164	0.37	0.582	0.55
Nasal bone/SN (°)	15	0.271	0.91	1.000	0.91	0.189	0.73
Nasal dorsum/FH (°)	15	0.104	0.73	0.271	0.73	0.271	0.91
Columella/FH (°)	15	0.334	0.73	1.000	0.37	0.433	0.73
Nasolabial angle (°)	15	1.000	0.73	0.096	0.91	0.096	1.10

Table 3 Comparison of cephalometric measurements for males and females at the mean age of 8.8 (T1), 13.8 (T2), and 17.8 (T3) years.

Parameter	T1 (*P*)	T2 (*P*)	T3 (*P*)
SNA (°)	0.357 n.s.	0.723 n.s.	0.892 n.s.
SNB (°)	0.448 n.s.	0.764 n.s.	0.153 n.s.
ANB (°)	0.348 n.s.	0.343 n.s.	0.031 n.s.
ST nasion/nasal tip (mm)	0.543 n.s	0.918 n.s.	0.817 n.s.
Nasion/nasal tip (mm)	0.699 n.s.	0.706 n.s.	0.372 n.s.
Rhinion/nasal tip (mm)	0.100 n.s.	0.348 n.s.	0.212 n.s.
Pg/nasal tip	0.340	0.604	0.770
Subnasale/nasal tip (mm)	0.718 n.s.	0.721 n.s.	0.078 n.s.
Upper Lip/nasal tip (mm)	0.641 n.s.	0.502 n.s.	0.441 n.s.
Stomion/nasal tip (mm)	0.773 n.s.	0.457 n.s.	0.312 n.s.
N/Me (mm)	0.445 n.s.	0.042*	0.002**
N/ANS (mm)	0.153 n.s.	0.831 n.s.	0.100 n.s.
ANS/Me (mm)	0.016*	0.002**	0.008**
ST nasion/subnasale (mm)	0.032*	0.234 n.s.	0.031*
Subnasale/stomion (mm)	0.048*	0.014*	0.005**
Stomion/ST Me (mm)	0.0589 n.s.	0.368 n.s.	0.023*
ANS/SLS (mm)	0.099 n.s.	0.086 n.s.	0.022*
SD/UL (mm)	0.016*	0.069 n.s.	0.005**
LI/LL (mm)	0.038*	0.022*	0.017*
Pg/Pgs (mm)	0.289 n.s.	0.595 n.s.	0.538 n.s.
Nasal bone/SN (°)	0.092 n.s.	0.124 n.s.	0.036*
Nasal dorsum/FH (°)	0.225 n.s.	0.298 n.s.	0.283 n.s.
Columella/FH (°)	0.770 n.s.	0.968 n.s.	0.909 n.s.
Nasolabial angle (°)	0.020*	0.187 n.s.	0.376 n.s.

$^*P<0.05$, $^{**}P<0.01$; n.s., not significant.

Changes in the nose, chin, and lips affect facial profile, and these may be key factors related to prediction of stability after orthodontic treatment (Prahl-Andersen *et al.*, 1995).

Previous studies (Alexander and Hitchcock, 1978; Johnson *et al.*, 1978; Björk *et al.*, 1984; Munandar and Snow, 1995) have reported that soft tissue analysis differs by population because nose and chin characteristics vary by heritage. Clearly, the soft tissue norms developed for one population may be unsuitable in diagnosis and treatment planning for another group. It is more appropriate to evaluate the nose, chin, and lips separately and then establish their interrelationship (Bishara, 1981; Bishara *et al.*, 1984, 1985). Some previous studies have established soft tissue norms for the Turkish population (Erbay and Caniklioğlu, 2002; Erbay *et al.*, 2002; Basciftci *et al.*, 2003), but little research has assessed longitudinal soft tissue growth in this population. Sayın and Türkkahraman (2004) reported that 64 per cent of the Turkish population had an Angle Class I malocclusion. Therefore, growth and development in patients with Angle Class I, who constitute the majority of the population, was examined.

Most studies agree that sexual dimorphism occurs in soft tissue growth changes at the nose, lips, and chin (Bishara, 1981; Bishara *et al.*, 1984, 1985; Nanda *et al.*, 1990). In the present investigation, changes between genders were also compared. In general, males tended to exhibit increased overall soft tissue growth compared with females and to grow more from T2–T3, a finding that has also been reported in previous studies (Nanda, 1971; Nanda *et al.*, 1990).

Bishara and Jakobsen (1998) reported similar changes in direction and magnitude for males and females but found that for most parameters, soft tissue profile changes occurred earlier in females (10–15 years) than in males (15–25 years).

Table 4 Mean and standard deviations (SD) of cephalometric measurements for females at the mean ages of 9.1 (T1), 14.1 (T2), and 18.1 (T3) years and comparison at these three time points.

Parameter	T1		T2		T3		T1–T2	T2–T3	T1–T3
	Mean	SD	Mean	SD	Mean	SD	*P*	*P*	*P*
SNA (°)	80.56	1.94	81.40	1.45	82.20	1.61	0.002**	0.013*	0.001***
SNB (°)	76.93	1.57	78.33	1.33	79.33	1.54	0.003**	0.001***	0.000***
ANB (°)	3.70	1.04	3.06	1.19	2.86	0.99	0.066 n.s.	0.458 n.s.	0.049*
ST nasion/nasal tip (mm)	20.73	2.18	25.46	1.95	28.86	3.13	0.000***	0.000***	0.000***
Nasion/nasal tip (mm)	25.80	3.60	30.86	3.04	34.80	2.09	0.000***	0.000***	0.000***
Rhinion/nasal tip (mm)	14.76	1.11	18.06	2.01	20.60	2.35	0.000***	0.001***	0.000***
Pg/nasal tip	28.25	3.02	33.50	3.05	36.20	3.65	0.000***	0.000***	0.000***
Subnasale/nasal tip (mm)	12.53	1.40	15.46	1.30	17.46	1.24	0.000***	0.000***	0.000***
Upper lip/nasal tip (mm)	11.56	3.20	14.93	1.22	16.73	1.90	0.000***	0.000***	0.000***
Stomion/nasal tip (mm)	17.46	1.84	20.93	2.37	22.93	2.86	0.000***	0.000***	0.000***
N/Me (mm)	108.33	3.61	116.26	2.28	124.60	2.64	0.000***	0.000***	0.000***
N/ANS (mm)	49.66	2.66	53.66	2.31	57.03	2.36	0.000***	0.000***	0.000***
ANS/Me (mm)	58.66	1.87	62.60	2.32	67.56	3.11	0.000***	0.000***	0.000***
ST nasion/subnasale (mm)	49.20	2.14	56.50	2.09	59.80	2.36	0.000***	0.001***	0.000***
Subnasale/stomion (mm)	18.80	2.04	20.13	2.09	21.73	2.37	0.000***	0.000***	0.000***
Stomion/ST Me (mm)	41.93	2.31	46.80	1.85	49.60	2.26	0.000***	0.000***	0.000***
ANS/SLS (mm)	11.00	1.64	13.06	1.33	14.26	1.16	0.000***	0.000***	0.000***
SD/UL (mm)	12.66	1.58	14.60	1.50	15.50	1.40	0.000***	0.001***	0.000***
LI/LL (mm)	11.76	1.32	13.60	1.18	14.53	1.35	0.000***	0.000***	0.000***
Pg/Pgs (mm)	9.66	0.81	10.66	1.04	11.66	1.49	0.000***	0.000***	0.000***
Nasal bone/SN (°)	109.20	6.01	116.33	5.87	119.26	6.43	0.000***	0.000***	0.000***
Nasal dorsum/FH (°)	56.40	4.76	55.00	4.17	54.20	4.31	0.033*	0.001***	0.003**
Columella/FH (°)	20.53	4.35	21.60	4.73	22.53	4.82	0.002**	0.000***	0.000***
Nasolabial angle (°)	115.46	6.80	108.73	3.05	108.00	3.77	0.000***	0.480 n.s.	0.001***

$*P<0.05$, $**P<0.01$, $***P<0.001$; n.s., not significant.

The present results indicated that females exhibited more changes between T1 and T2, whereas males changed more between T2 and T3. This finding suggests earlier growth completion for females than males.

Many orthodontists (Ricketts, 1968; Anderson *et al.*, 1973; Angelle, 1973) have examined the interrelationships between incisal movement and lip response during orthodontic treatment and have attempted to establish a movement ratio between these hard and soft tissue components. However, these ratios missed one element: the influence of growth on the soft tissue drape covering the anterior segment of the oral cavity. The current results demonstrate that the lips grow in length and thickness with age and that this growth differs by gender, supporting the results of Mamandras (1988).

The present findings clearly show that females tend to have smaller soft tissue dimensions than males; this was demonstrated in the relative thicknesses of the soft tissue of the lips and chin. Females had thinner upper lips at T1, which enlarged as they grew, until at T2 males and females had similar upper lip thicknesses. At the final measurement at T3, upper lips of females were often thinner than those of males by 2 mm or more because upper lip thickness increased less than that of males between T2 and T3. These data tend to support the findings of Subtelny (1959), Mauchamp and Sassouni (1973), and Riolo *et al.* (1986). Thus, with retraction of the upper incisors in 12-year-old females, little compensatory lip growth is to be expected, whereas a less detrimental effect might occur in males if the normal 2 mm increase in upper lip thickness occurs between 13.8 and 17.8 years of age.

Lip length and thickness are important elements of the facial profile. Lip position is affected by the placement and inclination of the maxillary and mandibular incisors and hence is responsive to orthodontic treatment. It is noteworthy that males have a greater average increase in upper and lower lip lengths than females (Nanda *et al.*, 1990).

Comparison of changes in upper and lower lip lengths revealed that the lips of male subjects elongated more than those of females between 8 and 18 years of age; supporting the findings of other research (Subtelny, 1959; Vig and Cohen, 1979; Mamandras, 1984). Although this gender difference is interesting biologically, its clinical significance is unimportant because the lengthwise growth appears to exceed the growth of the lower anterior face height, and therefore the lip seal is not negatively affected (Mamandras, 1988).

Mamandras (1988) reported significant increases in upper and lower lip thickness with age of males, compared with females over the same period. The vertical relationship between the lips and anterior teeth, particularly the maxillary incisors, is an important factor for aesthetics. However, it is lip thickness, and hence the fullness of the lower part of the facial profile, that influences treatment decisions, particularly when considering extraction of teeth and incisor retraction (Mamandras, 1988).

Table 5 Mean and standard deviations (SDs) of cephalometric measurements for males at the mean ages of 8.6 (T1), 13.6 (T2), and 17.6 (T3) years and comparison at these three time periods.

Parameter	T1		T2		T3		T1–T2	T2–T3	T1–T3
	Mean	SD	Mean	SD	Mean	SD	*P*	*P*	*P*
SNA (°)	79.96	1.54	81.23	1.06	82.13	0.97	0.001***	0.002**	0.000***
SNB (°)	76.53	1.24	78.46	1.06	80.00	0.84	0.000***	0.000***	0.000***
ANB (°)	3.36	0.85	2.70	0.86	2.43	0.94	0.027*	0.008**	0.000***
ST nasion/nasal tip (mm)	20.16	2.81	25.56	3.18	29.16	3.86	0.000***	0.000***	0.000***
Nasion/nasal tip (mm)	25.30	3.40	31.40	4.48	36.13	4.89	0.000***	0.000***	0.000***
Rhinion/nasal tip (mm)	15.66	1.71	18.83	2.37	21.90	3.16	0.000***	0.000***	0.000***
Pg/nasal tip	29.75	3.80	34.05	3.85	38.25	4.02	0.000***	0.000***	0.000***
Subnasale/nasal tip (mm)	12.73	1.59	15.70	2.13	18.86	2.64	0.000***	0.000***	0.000***
Upper Lip/nasal tip (mm)	11.13	1.55	14.53	1.92	17.46	3.09	0.001***	0.000***	0.000***
Stomion/nasal tip (mm)	16.41	5.10	20.26	2.46	23.93	2.43	0.000***	0.000***	0.000***
N/Me (mm)	109.53	4.77	119.93	6.27	130.53	6.13	0.000***	0.000***	0.000***
N/ANS (mm)	48.30	2.43	53.40	4.18	58.73	3.05	0.000***	0.000***	0.000***
ANS/Me (mm)	61.23	3.39	66.53	3.79	71.86	4.86	0.000***	0.000***	0.000***
ST nasion/subnasale (mm)	51.06	2.37	57.80	3.56	62.46	3.87	0.000***	0.000***	0.000***
Subnasale/stomion (mm)	20.26	1.83	22.13	2.09	24.13	1.92	0.001***	0.000***	0.000***
Stomion/ST Me (mm)	42.53	3.56	47.80	3.80	51.73	2.57	0.000***	0.000***	0.000***
ANS/SLS (mm)	11.93	1.33	13.93	1.33	15.46	1.50	0.000***	0.000***	0.000***
SD/UL (mm)	14.13	1.55	15.66	1.58	17.33	1.83	0.000***	0.000***	0.000***
LI/LL (mm)	12.73	1.09	14.66	1.23	16.86	1.92	0.000***	0.000***	0.000***
Pg/Pgs (mm)	9.13	1.72	10.33	2.16	12.06	1.98	0.001***	0.000***	0.000***
Nasal bone/SN (°)	112.33	3.49	119.06	3.17	124.06	5.45	0.000***	0.000***	0.000***
Nasal dorsum/FH (°)	58.46	4.35	56.66	4.43	56.00	4.69	0.003**	0.027*	0.001***
Columella/FH (°)	21.00	4.29	21.66	4.28	22.33	4.68	0.096 n.s.	0.027*	0.051 n.s.
Nasolabial angle (°)	109.80	5.73	107.20	3.14	106.93	2.60	0.066 n.s.	0.751 n.s.	0.073 n.s.

$^*P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$; n.s., not significant.

With regard to the lower lip, it was found that gender differences occurred mainly in the horizontal direction. Females stop growing earlier than males. Males had a more prominent lower lip than females. This cannot be explained by a greater lip thickness (less than 1 mm in boys) but is probably related to changes in the lower lip structure. The increase in lower lip thickness was mainly observed in males between T2 and T3, supporting the findings of Mamandras (1988).

Zylinski *et al.* (1992) reported a decreased nasolabial angle in individuals between 7 and 18 years of age. Nanda *et al.* (1990) studied subjects aged 7–17 years and Genecov *et al.* (1990) individuals aged 7–18 years; both studies demonstrated that nasolabial angle decreases with age in both males and females. A greater nasolabial angle in females than in males was observed in the present study which decreased with age more in females than in males. The reason for this may be that the tip of the nose is sustained by the nasal septum and ANS. ANS is carried forward with age, and accordingly point A moves relatively distally with age (Prahl-Andersen *et al.*, 1995).

Throughout the study period, face heights increased considerably. Males had a larger N/Me measurement than females, which particularly increased between T2 and T3. Vertical facial growth is known to be related to skeletal maturation and stomatic growth, and the present finding is consistent with previous research (Bishara *et al.*, 1985; Love *et al.*, 1990; Zylinski *et al.*, 1992; Thilander *et al.*, 2005).

Lower face height increased significantly during all growth periods in both males and females. A number of researchers have reported similar findings (McNamara, 1984; Love *et al.*, 1990; Gebeck and Merrifield, 1995; Gilliland *et al.*, 2001).

Previous investigations (Bowker and Meredith, 1959; Chaconas, 1969) have identified age-related changes in the nasal profile with reference to the soft tissues or skeletal planes. The size and shape of the analysed facial soft tissue were both significantly affected by age.

Erbay and Caniklioğlu (2002) found that Anatolian Turks had greater nasal and chin prominence than other subjects. Başçiftçi *et al.* (2003) found that males had more prominent noses and greater soft tissue chin thickness than females. These findings support those of Göyenç *et al.* (1992), who found that Anatolian Turkish men had more prominent chins than Anatolian Turkish women. The measurements at T3 (adult subjects) in the present study support these findings.

Previous investigations (Pelton and Elsasser, 1955; Subtelny, 1959) have shown that total facial convexity increases with age and can be expressed as a decreased angle. Bishara and Jakobsen (1998) found that the total facial convexity angle decreased from 5 to 45 years of age, from 148.1 to 142.3 degrees in males and from 147.1 to 140.2

Table 6 Mean and standard deviations (SDs) of cephalometric measurements for the total group at the mean ages of 8.8 (T1), 13.8 (T2), and 17.8 (T3) years and comparison at these three time periods.

Parameter	T1		T2		T3		T1–T2	T2–T3	T1–T3
	Mean	SD	Mean	SD	Mean	SD	*P*	*P*	*P*
SNA (°)	80.26	1.75	81.31	1.25	82.16	1.30	0.000***	0.000***	0.000***
SNB (°)	76.73	1.41	78.40	1.18	79.66	1.26	0.000***	0.000***	0.000***
ANB (°)	3.53	0.95	2.88	1.03	2.65	0.97	0.004**	0.023*	0.000***
ST nasion/nasal tip (mm)	20.45	2.49	25.51	2.60	29.01	3.46	0.000***	0.000***	0.000***
Nasion/nasal tip (mm)	25.55	3.45	31.13	3.77	35.46	4.01	0.000***	0.000***	0.000***
Rhinion/nasal tip (mm)	15.21	1.49	18.45	2.19	21.25	2.81	0.000***	0.000***	0.000***
Pg/nasal tip	29.00	3.41	33.77	3.45	37.22	3.83	0.001***	0.001***	0.001***
Subnasale/nasal tip (mm)	12.63	1.47	15.58	1.74	18.16	2.15	0.000***	0.000***	0.000***
Upper Lip/nasal tip (mm)	11.35	2.48	14.73	1.59	17.10	2.55	0.000***	0.000***	0.000***
Stomion/nasal tip (mm)	16.93	3.81	20.60	2.40	23.43	2.66	0.000***	0.000***	0.000***
N/Me (mm)	108.93	4.20	118.10	4.99	127.56	5.53	0.000***	0.000***	0.000***
N/ANS (mm)	48.98	2.60	53.53	3.32	57.88	2.82	0.000***	0.000***	0.000***
ANS/Me (mm)	59.95	2.99	64.56	3.68	69.71	4.57	0.000***	0.000***	0.000***
ST nasion/subnasale (mm)	50.13	2.41	57.15	2.95	61.13	3.43	0.000***	0.000***	0.000***
Subnasale/stomion (mm)	19.53	2.04	21.13	2.30	22.93	2.44	0.000***	0.000***	0.000***
Stomion/ST Me (mm)	42.23	2.96	47.30	2.98	50.66	2.61	0.000***	0.000***	0.000***
ANS/SLS (mm)	11.46	1.54	13.50	1.38	14.86	1.45	0.000***	0.000***	0.000***
SD/UL (mm)	13.40	1.71	15.13	1.61	16.41	1.85	0.000***	0.000***	0.000***
LI/LL (mm)	12.25	1.29	14.13	1.30	15.69	1.76	0.000***	0.000***	0.000***
Pg/Pgs (mm)	9.40	1.35	10.50	1.67	11.86	1.73	0.000***	0.000***	0.000***
Nasal bone/SN (°)	110.76	5.09	117.70	4.84	121.66	6.34	0.000***	0.000***	0.000***
Nasal dorsum/FH (°)	57.43	4.60	55.83	4.31	55.10	4.52	0.000***	0.000***	0.000***
Columella/FH (°)	20.76	4.25	21.63	4.43	22.43	4.67	0.001***	0.000***	0.000***
Nasolabial angle (°)	112.63	6.82	107.96	3.14	107.46	3.23	0.000***	0.443 n.s.	0.000***

$^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$; n.s., not significant.

degrees in females. They reported that the increased total facial convexity is primarily due to increased nasal prominence relative to the rest of the soft tissue profile with growth (Bishara and Jakobsen, 1998). Some researchers (Snedecor and Cochran, 1972; Nanda *et al.*, 1990) have acknowledged that the facial profile tends to become more convex over time as a result of continued growth of the nose and chin. The effect of this on the profile is a relative retrusion of the upper and lower lips (Blanchette *et al.*, 1996). While total facial convexity angle was not measured, it was found that nasal prominence increased more than chin prominence, and this increase continued from T2 to T3. This finding could be seen as an increase in facial convexity.

Björk (1951), Lande (1952), Riolo *et al.* (1974), Bishara and Jakobsen (1985), and Chung and Wong (2002) observed decreased convexity with growth. This finding is not consistent with the present results, but the difference might be attributable to racial and ethnic differences in the study populations.

Conclusions

1. All measurements except ANB angle, nasolabial angle, and nasal dorsum/FH increased significantly with age.
2. Generally, males had larger facial soft tissue measurements than females, and these measurements increased more in males.
3. Males exhibited more growth than females between T2 and T3.
4. Growth of the facial soft tissues follows that of the hard tissues, resulting in a convex profile.

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