Original Article

Ethnic Differences in the Soft Tissue Profile of Korean and European-American Adults with Normal Occlusions and Well-Balanced Faces

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Abstract: Orthodontic diagnosis typically includes comparing a patient's cephalometric measurements to standard values. Lateral cephalometric norms, however, may be specific to an ethnic group and cannot always be applied to other ethnic types. The purpose of this study was to compare the soft tissue profiles obtained from Korean and European-American adults with normal occlusions and well-balanced faces, in order to understand the ethnic differences in the soft tissue profile between these two ethnic groups. The lateral cephalograms of 60 Korean (30 men and 30 women) and 42 European-American adults (15 men and 27 women) were traced and digitized by one investigator. Ten angular measurements of facial form and seven linear and angular measurements of lip position were computed. A comparison of the slope of the forehead showed no significant differences between the two groups. The Korean sample, however, had a lower angle of nasal inclination and a higher degree of lip protrusion compared to the European-American adults. Chin protrusion of the Koreans was less prominent than that of the European-Americans. These differences between ethnic groups should be taken into consideration when formulating an orthodontic treatment plan for patients of varying ethnic backgrounds. (*Angle Orthod* 2002;72:72–80.)

Key Words: Soft tissue profile; Ethnic difference; Cephalometric; Facial form; Lip position

INTRODUCTION

One of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the patient's soft tissue profile.[1] Investigators have developed numerous methods of analysis to interpret the diagnostic information that the lateral cephalogram provides.[2–6] In orthodontic practice, a diagnosis is determined, in part, by comparing a patient's cephalometric measurements to standard values. Lateral cephalometric norms, however, may be specific to an ethnic group and cannot always be applied to other ethnic types. In spite of possible ethnic differences, most classical cephalometric standards are based on sample populations of people with European-American ancestries.

For this reason, attempts have been made to investigate the differences of the human face among various ethnic groups including African-Americans,[7–17] Africans,[18–21] Chinese,[7,22–24] Japanese,[7,25–29] Koreans,[30] Indians,[31] Saudi Arabians,[32] Mexican-Americans,[33] Brazilians,[34] and Puerto Ricans.[35] In a comparative study of Japanese and European-American adults, Miyajima et al[27] reported greater ethnic differences in soft tissue relationships than in skeletal and dentitional relationships. The issue of soft tissue profiles, however, played a small part in the majority of the studies mentioned above.* Some of these studies,† did not present even a single variable regarding the soft tissue profile, and substantial studies on this issue are lacking.[8,21,24,29]

A recent report by Hwang and co-workers[36] comparing two different tracing methods of quantifying the soft tissue

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Accepted: August 2001. Submitted: April 2001.

References 10, 13–15, 19, 23, 25–28, 30, 32, 33, 35.
†*References 7, 9, 11, 16–18, 20, 22, 31, 34.*

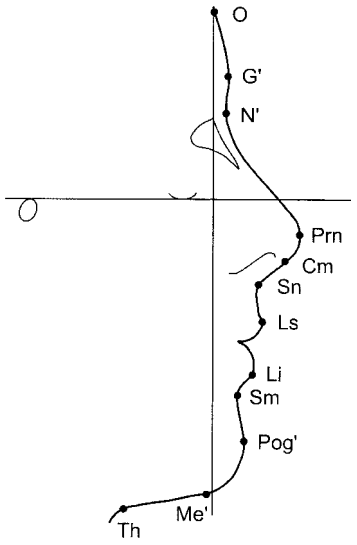

FIGURE 1. Soft tissue landmarks used in this study. O indicates intersection of the NP with the forehead; G′ (soft tissue glabella), the most prominent point in the midsagittal plane of the forehead; N′ (soft tissue nasion), the most concave point in the tissue overlying the area of the frontonasal suture; Prn (pronasale), the most prominent point of the nose; Cm (columella), the most anterior soft tissue point on the columella (nasal septum) of the nose; Sn (subnasale); the point at which the columella merges with the upper lip in the midsagittal plane; Ls (labrale superius), the most anterior point on the upper lip; Li (labrale inferius), the most anterior point on the lower lip; Sm (supramentale), the point of greatest concavity in the midline of the lower lip between the labrale inferius and the soft tissue pogonion; Pog′ (soft tissue pogonion), the most anterior point on the soft tissue chin; Me′ (soft tissue menton), the most inferior point on the soft tissue chin; and Th (throat), the intersection between the submental area and the tangent line of the neck.

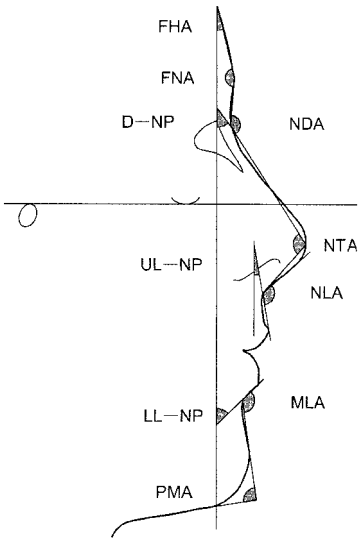

FIGURE 2. Angular measurements for facial form used in this study. FHA (forehead angle) indicates NP-OG'; FNA (frontonasal angle). O-G'-N'; NDA (nasal depth angle), G'-N'-Prn; D-NP (dorsum-NP angle), N'Prn-NP; NTA (nasal tip angle), N'-Prn-Sn; NLA (nasolabial angle), Cm-Sn-Ls; UL-NP (upper lip-NP angle), SnLs-NP; LL-NP (lower lip-NP angle), LiSm-NP; MLA (mentolabial angle): Li-Sm-Pog'; and PMA (pogonion-menton angle), SmPog'-ThMe'.

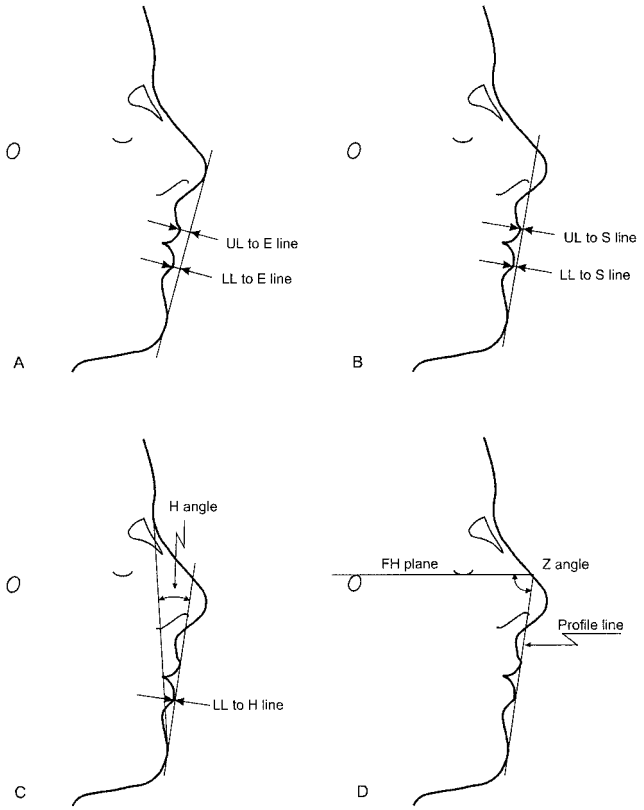

FIGURE 3. Analysis to assess lip position. (A) Ricketts[4] analysis: a reference line, the ''E'' line, was drawn from the tip of the nose to the soft tissue pogonion. The distances from the upper lip and lower lip to the E line were measured in millimeters. (B) Steiner[2] analysis: the upper reference point is at the center of the S-shaped curve between the subnasale and the nasal tip. The inferior landmark is soft tissue pogonion. The distances from the upper lip and lower lip to the reference line were measured. (C) Holdaway[6] analysis: an angle, termed the ''H angle,'' between the soft tissue facial plane (N′-Pog′) and a line tangent to the upper lip and soft tissue pogonion (''H'' line), and the distance from the lower lip to H line were measured. (D) Merrifield[3] analysis: the inner angle between the profile line (tangent to the soft tissue chin and the more prominent point of the upper lip or lower lip) and the FH plane was measured, called the ''Z'' angle.

profile, the anatomic point and the tangent line methods, showed significant differences between the two approaches. This study also demonstrated that intra- and interobserver errors occur with either method. The results of this study indicated that a precise description of the methodology used in the analysis of soft tissue should be provided. In addition, the same investigator should perform the actual cephalometric tracing in order to eliminate possible interobserver errors. Despite the importance of interobserver errors, however, only one ethnic group was used as a source material in most studies regarding ethnic difference of soft tissue profile.‡ A literature review reveals that only five

‡*References 7–12, 14–17, 20–22, 24–26, 28–35.*

TABLE 1. Comparison of European-American Adult Variables Between Men and Women[a]

	Men (N = 15)		Women (N = 27)		
	Mean	SD	Mean	SD	Significance
Facial form					
FHA	18.56	3.93	13.96	1.77	***
FNA	153.47	7.07	159.45	3.57	**
NDA	139.90	6.07	142.63	4.56	ns
D-NP	32.12	3.22	30.79	3.43	ns
NTA	99.37	7.14	97.33	4.38	ns
NLA	112.05	9.86	109.71	7.60	ns
UL-NP	3.77	7.67	2.79	6.63	ns
LL-NP	34.03	10.04	35.51	8.97	ns
MLA	133.34	11.75	132.99	9.08	ns
PMA	90.64	8.26	88.73	8.72	ns
Lip position					
Ricketts					
Upper lip	−6.37	2.54	−6.46	2.08	ns
Lower lip	−4.63	2.50	−3.98	2.23	ns
Steiner					
Upper lip	−2.87	2.26	−3.06	1.93	ns
Lower lip	−2.07	2.15	−1.74	2.19	ns
Holdaway					
H Angle	11.03	3.33	10.41	3.14	ns
Lower lip	−0.20	1.25	0.13	1.20	ns
Merrifield					
Z angle	82.13	5.43	80.96	5.42	ns

[a] N indicates number of patients; SD, standard deviation, and ns, not significant.
** $P < .01$.
*** $P < .001$.

articles[13,18,19,23,27] analyzed more than one ethnic group simultaneously.

Jacobson[18] was one of the first to analyze cephalograms from two groups to determine ethnic differences, investigating South African Negroes and Caucasoids. No soft tissue variables were considered, however, as all cephalograms were taken from dry skulls with the jaws wired in occlusion. Bacon and co-workers[19] compared cephalometric norms between Caucasian and African Bantu students living in France. They used only one variable, lower lip position, in the evaluation of the soft tissue. Soft tissue analysis also was considered, in part, in a comparative study of southern Chinese and British Caucasians living in Hong Kong by Cooke and Wei.[23] An extensive comparative study was conducted by Connor and Moshiri.[13] They used cephalograms taken from African-American and European-American adults to establish orthognathic surgery norms for African-American patients. To provide some information for Mongoloid patients, Miyajima and coworkers[27] compared the craniofacial structure of Japanese and European-American adults. Although they selected ideal occlusion individuals with well-balanced faces for their sample, the soft tissue analysis was confined to only four variables.

Thus, a review of literature reveals that a comprehensive comparative study is necessary to investigate ethnic differences in soft tissue profile, analyzing the soft tissue of two ethnic groups simultaneously in a standardized manner. The purpose of the present investigation was to compare soft tissue profiles obtained from Korean and European-American adults with normal occlusion and well-balanced faces in order to determine the differences of the soft tissue profile between these two ethnic groups.

MATERIALS AND METHODS

Two groups of untreated adults were compared: one of Korean origin and one of European-American origin.

Ann Arbor Sample

Subjects were chosen from the normal occlusion data of the University of Michigan.[1,37] All subjects were of European-American ancestry and were judged to have balanced facial esthetics and normal occlusion. After a normal occlusion sample was identified through clinical examination, a subsample was selected for facial balance. On the basis of an untraced lateral head film, three American orthodontists unanimously agreed that each subject in the subsample had a well-balanced face. The subjects in this sample had no history of orthodontic treatment or extensive restorative dentistry. The sample was composed of 15 men and 27

TABLE 2. Comparison of Korean Adult Variables Between Men and Women[a]

	Men (N = 30)		Women (N = 30)		
	Mean	SD	Mean	SD	Significance
Facial form					
FHA	17.18	3.34	13.09	2.41	***
FNA	150.31	4.92	159.33	3.70	***
NDA	139.10	5.23	144.98	4.11	***
D-NP	28.41	2.67	27.44	2.90	ns
NTA	102.15	4.73	105.50	4.66	**
NLA	91.11	8.12	92.00	9.55	ns
UL-NP	20.37	7.66	21.98	6.79	ns
LL-NP	54.88	10.02	49.01	10.88	*
MLA	123.10	12.36	130.64	11.88	*
PMA	94.16	9.14	94.48	9.02	ns
Lip position					
Ricketts					
Upper lip	−0.55	2.40	0.02	1.89	ns
Lower lip	0.98	2.06	1.40	2.23	ns
Steiner					
Upper lip	2.62	2.17	2.60	1.74	ns
Lower lip	2.87	1.80	2.97	2.07	ns
Holdaway					
H Angle	17.70	2.88	17.12	2.86	ns
Lower lip	1.32	1.17	1.37	1.35	ns
Merrifield					
Z angle	71.75	5.40	71.92	6.58	ns

[a] N indicates number of patients; SD, standard deviation; and ns, not significant.
* $P < .05$.
** $P < .01$.
*** $P < .001$.

women with an average age of 25 years and 1 month (range: 18 years 9 months to 33 years 9 months) and 26 years and 4 months (range: 19 years 11 months to 34 years 11 months), respectively.

Kwangju sample

The Korean sample was selected from university students in Kwangju. For the first step of the selection process, a clinical examination was carried out to determine the status of the occlusion; those subjects who were judged to have a normal occlusion were selected. None of the subjects had previous orthodontic treatment or prosthetic replacement of teeth.

The second step in subject identification was to obtain a set of study models. On the basis of the study casts, subjects who showed Class I molar and canine relationships with no or minimal crowding were selected. Any subject who presented with crowding greater than 2 mm, spacing greater than 1 mm, or a dental midline discrepancy greater than 1 mm was excluded from the samples. From a survey of 4,500 students, 41 men and 49 women were selected as subjects with normal occlusion.

The final step in subject selection was to obtain a lateral cephalogram. All cephalograms were taken with the lip at rest. On the basis of the untraced cephalogram, 3 Korean orthodontists selected a subsample of subjects who were judged to have well-balanced faces. The final Kwangju sample included 30 men and 30 women; their average age was 18 years and 9 months (range: 17 years 6 months to 23 years 6 months) and 18 years and 10 months (range: 17 years 11 months to 20 years 9 months), respectively.

Facial Form and Lip Position Assessment

One investigator traced the lateral cephalograms on acetate paper using a pencil with a 0.3 mm diameter lead. The anatomical porion and orbitale were established as the Frankfort horizontal line. The nasion perpendicular (NP) was established by dropping a line inferiorly from nasion that was perpendicular to the Frankfort horizontal line. [38] Twelve soft tissue cephalometric landmarks were used for the angular and linear measurements (Figure 1).[36]

Facial form was evaluated using 10 angular measurements (Figure 2).[36]

Lip position was evaluated using four widely accepted lip analyses (Figure 3). Tracings of the lateral cephalograms were digitized using a computer program (Quick Ceph Image Pro™, Orthodontic Processing, Coronado, Calif). Ten angular measurements for facial form assessment and 7 lin-

TABLE 3. Adult Male Comparisons of Group means Between Ann Arbor and Kwangju Samples[a]

	Ann Arbor (N = 15)		Kwangju (N = 30)		
	Mean	SD	Mean	SD	Significance
Facial form					
FHA	18.56	3.93	17.18	3.34	ns
FNA	153.47	7.07	150.31	4.92	ns
NDA	139.90	6.07	139.10	5.23	ns
D-NP	32.12	3.22	28.41	2.67	***
NTA	99.37	7.14	102.15	4.73	ns
NLA	112.05	9.86	91.11	8.12	***
UL-NP	3.77	7.67	20.37	7.66	***
LL-NP	34.03	10.04	54.88	10.02	***
MLA	133.34	11.75	123.10	12.36	*
PMA	90.64	8.26	94.16	9.14	ns
Lip position					
Ricketts					
Upper lip	−6.37	2.54	−0.55	2.40	***
Lower lip	−4.63	2.50	0.98	2.06	***
Steiner					
Upper lip	−2.87	2.26	2.62	2.17	***
Lower lip	−2.07	2.15	2.87	1.80	***
Holdaway					
H Angle	11.03	3.33	17.70	2.88	***
Lower lip	−0.20	1.25	1.32	1.17	***
Merrifield					
Z angle	82.13	5.43	71.75	5.40	***

[a] N indicates number of patients; SD, standard deviation, and ns, not significant.
* $P < .05$.
** $P < .001$.

ear and angular measurements for lip position assessment were computed in each tracing.

Means and standard deviations of the measurements for the Korean and the European-American samples were calculated. Student's *t*-tests were used to determine gender differences within the same race and ethnic differences between the Korean and the European-American samples.

RESULTS

Comparison of Sexual Dimorphism

The results comparing the men and women in the Ann Arbor samples are presented in Table 1. In the comparison of facial form, only two variables showed significant differences between men and women. The forehead angle of the male was larger, and the frontonasal angle was smaller, indicating a more anterior positioning of the forehead in men. All variables associated with lip position showed no gender differences (Table 1).

The results showing sexual dimorphism of the Korean subjects are listed in Table 2. In the comparison of facial form, 6 of 10 measurements showed significant differences between men and women. Although the forehead angle was larger, the frontonasal angle and the nasal depth angle were smaller in the male subjects. These results suggest that forehead is positioned more anteriorly in Korean men than in Korean women.

Unlike the American subjects, the Korean subjects showed sexual dimorphism in the nose, the lower lip, and the mentolabial sulcus area. The nasal tip angle was smaller in men, indicating that the male nose is pointed. The lower lip to NP angle was larger and the mentolabial angle was smaller in men, indicating that Korean men have a slightly more protrusive lower lip and a deeper mentolabial sulcus than Korean women. All lip position variables showed no differences between the men and women (Table 2).

Taken together, the Korean samples showed slightly greater sexual dimorphism than the European-American samples in facial form, whereas no gender differences in lip position were present in either group.

Comparison of Male Subjects

The results comparing men in the Ann Arbor sample with the men in the Kwangju sample are presented in Table 3. In the comparison of facial form, 5 of 10 variables showed significant differences between the two groups. The shape of the forehead, the forehead angle, the frontonasal angle, and the nasal depth angle showed no differences.

Of the variables of nasal form, the dorsum of the nose

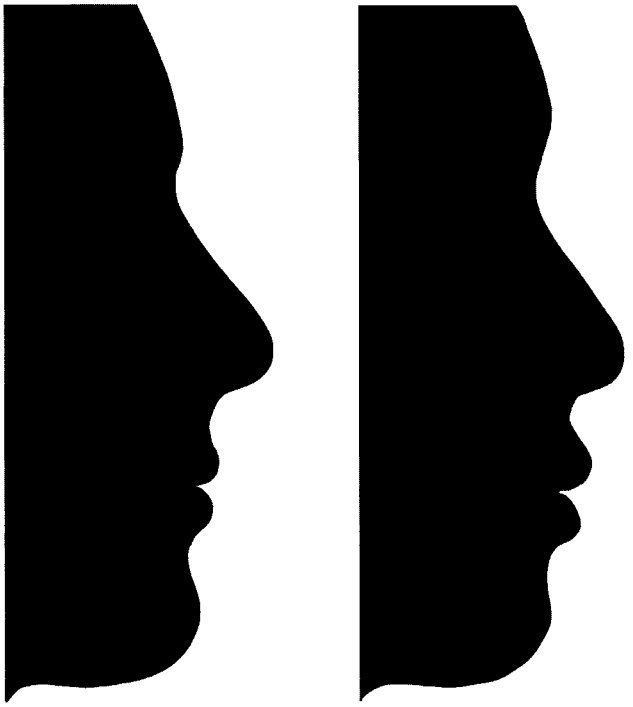

FIGURE 4. A comparison of the soft tissue profiles for European-American male and Korean male samples. The present tracing was generated from the Quick Ceph Image Pro™ using the function of ''composite'' (magnification rate, ×.5).

to NP angle of the Korean subjects showed smaller values, demonstrating a bluntness of the nose. Regarding the shape of the upper lip, the nasolabial angle was smaller and the upper lip to NP angle was greater in the Korean subjects. For the shape of the lower lip, the lower lip to NP angle was larger and the mentolabial angle was smaller in the Koreans. These results would suggest that the upper and lower lips are more redundant and anteriorly positioned in Koreans. When comparing lip position, all variables showed significant differences between the two groups. Every analysis demonstrated that the upper and lower lips were positioned more anteriorly in the Korean subjects (Table 3, Figure 4).

Comparison of Female Subjects

The results comparing women in the Ann Arbor sample with women in the Kwangju sample are presented in Table 4. In the comparison of facial form, 7 of the 10 variables showed significant differences between the two groups. The shape of the forehead, the forehead angle, and the frontonasal angle showed no differences. On the other hand, all variables concerning the shape of the nose showed differences between the two groups. The nasal depth angle was greater and the dorsum to NP angle was smaller in the Korean subjects. The nasal tip angle was larger in the Korean subjects. These values indicate that Korean women demonstrate a bluntness of the nose similar to that of Korean men.

Regarding the shape of the upper lip, the nasolabial angle was smaller and the upper lip to NP angle was larger in Korean women than in European-American women. For the shape of the lower lip, the lower lip to NP angle was greater in the Koreans. As in the male subjects, the upper and lower lips were more redundant in the Korean female subjects than in European-American subjects. Concerning the shape of the chin, the pogonion-menton angle of the Koreans was larger, whereas the mentolabial angle showed no differences between the two groups. In the comparison of the lip position, every analysis showed that the upper and lower lips were positioned anteriorly in the Korean subjects (Table 4, Figure 5).

DISCUSSION

The nature of the soft tissue profile is affected by many factors, including ethnicity. As the profile varies according to malocclusion type, the present study used only Class I subjects. On the other hand, skeletal variations may exist in subjects with a Class I molar relationship. For example, Casko and Shepherd[39] revealed that cephalometric values for a sample of normal occlusions showed variation far beyond the mean values often used as treatment goals. For this reason, the present study selected a subsample of subjects who were judged to have well-balanced faces as well.

Another important issue in a comparative cephalometric study of the soft tissue profile is the manner in which the measurements were obtained. To reveal differences between two ethnic types, original cephalometric tracings of both ethnic groups should be traced at the same time following the same protocol. Although a number of studies[8,21,24,29] have been conducted to identify ethnic differences in the soft tissue profile, no previous study has analyzed the lateral cephalograms of two ethnic groups simultaneously. For the present study, two sample groups were compared directly. One investigator traced both groups of cephalograms in order to eliminate interobserver errors.[36]

In the comparison of sexual dimorphism of facial form, the Korean subjects showed slightly greater sexual dimorphism than did the European-American subjects. The Ann Arbor subjects showed a difference only in the forehead area; the forehead angle was larger and the frontonasal angle was smaller in men, indicating a more prominent male forehead. The Korean subjects, however, showed sexual dimorphism in the nose, lower lip, and the mentolabial sulcus area. The nasal tip angle was more acute, indicating a more pointed nasal shape in the Korean men. In addition, the lower lip to NP angle was more obtuse, and the mentolabial angle was smaller in men, suggesting a more protrusive lower lip and a deeper mentolabial sulcus in men.

On the other hand, the lack of difference in the mea-

TABLE 4. Adult Female Comparisons of Group Means Between Kwangju and Ann Arbor Samples[a]

	Ann Arbor (N = 27)		Kwangju (N = 30)		
	Mean	SD	Mean	SD	Significance
Facial form					
FHA	13.96	1.77	13.09	2.41	ns
FNA	159.45	3.57	159.33	3.70	ns
NDA	142.63	4.56	144.98	4.11	*
D-NP	30.79	3.43	27.44	2.90	***
NTA	97.33	4.38	105.50	4.66	***
NLA	109.71	7.60	92.00	9.55	***
UL-NP	2.79	6.63	21.98	6.79	***
LL-NP	35.51	8.97	49.01	10.88	***
MLA	132.99	9.08	130.64	11.88	ns
PMA	88.73	8.72	94.48	9.02	*
Lip position					
Ricketts					
Upper lip	−6.46	2.08	0.02	1.89	***
Lower lip	−3.98	2.23	1.40	2.23	***
Steiner					
Upper lip	−3.06	1.93	2.60	1.74	***
Lower lip	−1.74	2.19	2.97	2.07	***
Holdaway					
H Angle	10.41	3.14	17.12	2.86	***
Lower lip	0.13	1.20	1.37	1.35	**
Merrifield					
Z angle	80.96	5.42	71.92	6.58	***

[a] N indicates number of patients; SD, standard deviation; and ns, not significant.
* $P < .05$.
** $P < .01$.
*** $P < .001$.

surement of the pogonion-menton angle seems to indicate a similar shaped menton area. This, however, is not always the case. The pogonion-menton angle is constructed from two lines, the Sm-Pog′and the Th-Me′. When the inclinations of the two lines change in the same direction, the angle remains the same. The lack of difference in the pogonion-menton angle may suggest that the Th-Me′ line is flatter in men because the mentolabial angle, Li-Sm-Pog′, is smaller in men. Overall, the results of the comparison of sexual dimorphism demonstrate that the Korean subjects have a more gender-specific facial form than the European-Americans.

Regarding the ethnic differences, all variables except for the forehead area showed significant differences in both men and women. The forehead area showed significant gender differences, indicating that the degree of forehead slope is likely gender specific, not racially specific.

With regard to nasal shape, the dorsum to NP angle of Korean subjects showed smaller values, suggesting a bluntness of the nose. If a nose has a blunt shape, the nasal tip angle should be large. In fact, the nasal tip angle was larger in Korean women than in women from the Ann Arbor sample. The nasal tip angle in men, however, did not show a statistically significant difference between the two groups. This lack of difference is due partly to the less upward inclination of the Sn-Prn line, a lower component of the nasal tip angle, of Korean men.

The most significant differences between the two sample groups occurred in the lip area. The upper lip to NP angle, and the lower lip to NP angle, were greater in the Korean subjects, indicating a more redundant and more prominent lip in Koreans. If the upper and lower lips are positioned anteriorly, both the nasolabial and mentolabial angles should be smaller. The mentolabial angle of women, however, did not show a statistically significant difference between the two groups. This lack of difference is due to the bluntness of the chin in Korean women. Other than in the mentolabial angle, which was affected negatively by the shape of adjacent tissue, the nasolabial angle differed greatly between the Koreans and the European-Americans: 91° and 113° for men and 92° and 110° for women, respectively.

Regarding the shape of chin, the pogonion-menton angle showed larger values in the Korean subjects, indicating bluntness. The men, however, did not show a statistically significant difference. This lack of difference seems to be due to variation in inclination of the submental area, the Th-Me′ line. The degree of chin bluntness in Korean men

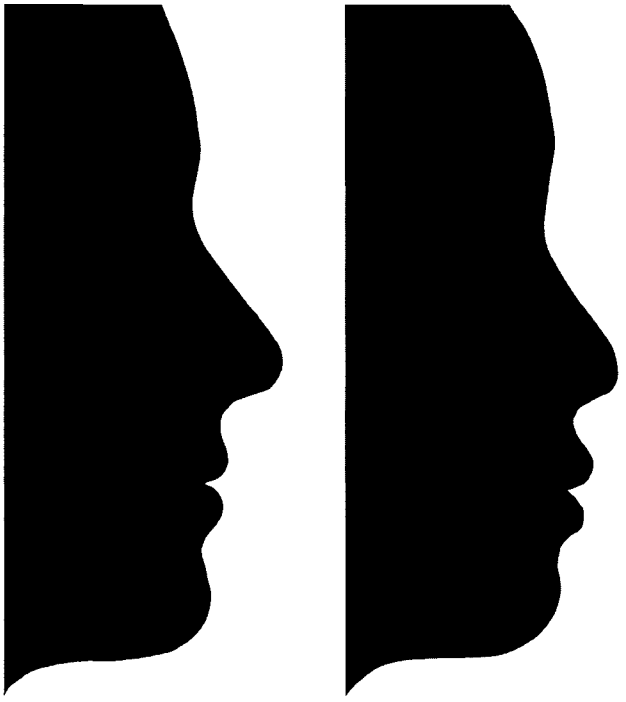

FIGURE 5. A comparison of the soft tissue profiles for European-American female and Korean female samples. The present tracing was generated from the Quick Ceph Image Pro™ using the function of "composite" (magnification rate, ×.5).

was masked partly by the lesser degree of upward inclination of the Th-Me′ line.

In the comparison of lip position, all variables showed significant differences between the two groups. Every analysis[2–4,6] demonstrated that the upper and lower lips were positioned more anteriorly in the Korean subjects. The average values for the lip position obtained in the study can be used in orthodontic diagnosis of Korean patients. Every orthodontist, however, has his or her preference of analysis. The results of the study, therefore, may not help some practitioners. Furthermore, there may be a discrepancy in landmark identification, drawing methods, or both.[36] To overcome these problems, composite tracings are presented in Figures 4 and 5. These tracings can be used to calculate the norms of any soft tissue analysis.

SUMMARY

In summary, we compared the soft tissue profiles of Korean and European-American adults with normal occlusion and well-balanced faces. A comparison of forehead slope showed no significant differences between the two groups. The Korean sample, however, showed a lower angle of nasal inclination and a greater degree of lip protrusion compared to the European-American sample. Chin protrusion of the Koreans was less prominent than to that of the European-Americans. These differences should be considered when formulating an orthodontic treatment plan for patients of varying ethnic backgrounds.

ACKNOWLEDGMENT

This study was supported financially by Chonnam National University.

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