Changes in soft tissue profile of African-Americans following extraction treatment

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A number of African-American patients show dentofacial characteristics of bimaxillary dentoalveolar protrusion. Bimaxillary protrusion is characterized by protrusive teeth in both jaws and a greater than average degree of lip prominence. Often the sole purpose of extracting premolars in patients with bimaxillary protrusion is to create space to retract the anterior teeth in order to reduce the procumbency of the lips. Although changes in facial soft tissues as a result of incisor retraction have been studied extensively in Caucasians, such changes have not been well documented in the African-American population.

The purpose of this study was to determine the extent to which lip procumbency is affected by incisor retraction in African-American adolescents. A reliable ratio between incisor retraction and lip retraction would help the clinician more reliably predict changes in a patient's soft tissue profile as a result of incisor retraction. This, in turn, could help the clinician make extraction decisions and determine the amount of incisor retraction required to reduce lip procumbency. If the ratio of hard tissue retraction to soft tissue retraction was found to differ in males and females, as has been suggested by a previous study,[1] then the patient's sex would be an important consideration in planning treatment.

The objective of this study, therefore, was to assess the changes in the soft tissue profile subsequent to the extraction of four premolars and retraction of incisors in African-Americans with bimaxillary protrusion. In addition, the aim of the study was to compare the soft tissue responses between males and females and to de-

Abstract

The purpose of this investigation was to determine changes in soft tissue profile of African-Americans following orthodontic treatment involving extraction of four premolars. The sample consisted of pretreatment and postreatment lateral cephalometric radiographs of 30 males and 30 females of African-American descent exhibiting bimaxillary protrusion. The age of the patients ranged between 10 years 4 months and 17 years 6 months at the start of treatment. Average time between pretreatment and postreatment radiographs was 2 years 11 months in the male group and 3 years 3 months in the female group. Changes in the dentofacial complex and facial soft tissue as a result of treatment and growth were evaluated with cephalometric analysis. Student's t-tests were performed to compare differences. Nasolabial angle increased 9.1° in males and 7.1° in females. Upper lip procumbency relative to SnPg' decreased 1.5 mm in males and 1.7 mm in females. Lower lip retraction relative to SnPg' was 2.7 mm in males and 2.5 mm in females.

Key words

African-American • Bimaxillary protrusion • Extraction • Soft tissue profile • Lips

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Figure 1
Soft tissue angular measurements:
1. Glabella-subnasale-soft tissue pogonion
2. Nasolabial angle
3. Mentolabial sulcus
4. Lip thickness at upper sulcus
5. Lip thickness at labrale superior
6. Lip thickness at labrale inferior
7. Lip thickness at lower sulcus
8. Constructed Frankfort horizontal
9. Vertical reference line

Figure 2
Soft tissue linear measurements:
1. Upper lip length;
2. Lower lip length;
3. SnPg' to upper lip;
4. SnPg' to lower lip

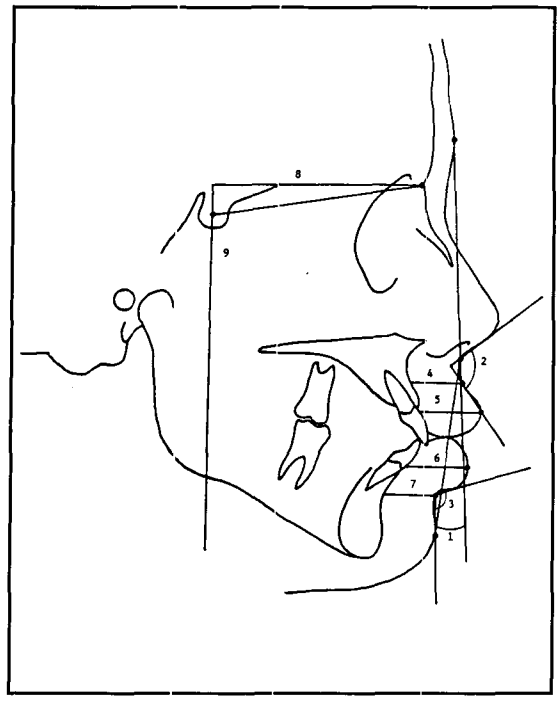

Figure 1

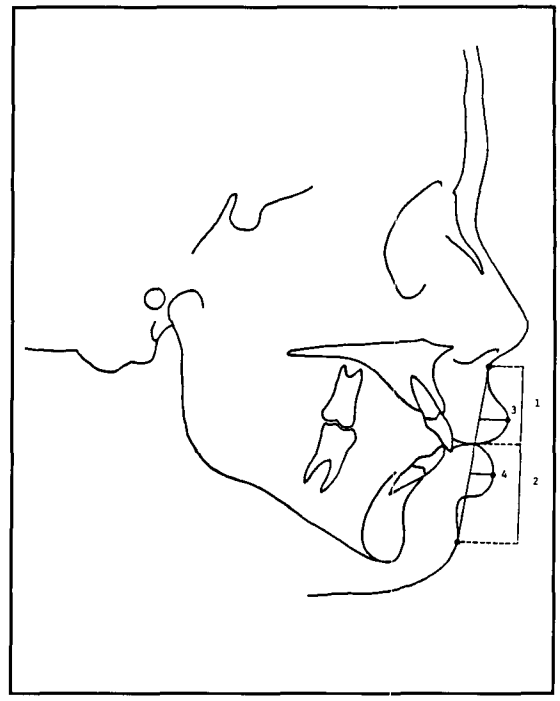

Figure 2

termine the ratios of hard tissue retraction to soft tissue change for males and females.

Materials and methods

Sample

The sample for this study consisted of pre- and posttreatment lateral cephalometric radiographs of 60 black adolescent patients—30 males and 30 females—who presented with bimaxillary protrusion. The sample was derived from patients treated in the Department of Orthodontics at Case Western Reserve University and three private orthodontic practices.

The mean age of the patients at the time the pretreatment cephalometric radiographs were taken was 13 years 2 months for males (range, 10 years 4 months to 17 years 6 months) and 13 years 7 months for females (range 10 years 4 months to 17 years 6 months). The mean age at which the posttreatment cephalometric radiograph was taken was 16 years for males and 16 years 10 months for females. Average time between pretreatment and posttreatment radiographs was 2 years 11 months for males and 3 years 3 months for females.

The following criteria were used in selection: Class 1 molar relation (± 1 mm), interincisal angle 120° or less, overbite 0% to 50% and overjet 0 to 7 mm. Upper incisor retraction, as determined by maxillary superimposition, showed a range of 1 to 9 mm, with a mean of 4.15 mm in males and 5.48 mm in females. The amount of lower incisor retraction as determined by mandibular superimposition, ranged from 2 to 9 mm, with a mean of 3.17 mm in males and 3.98 mm in females.

The lateral cephalometric radiographs were taken with the teeth in centric occlusion and the lips lightly touching, in what appeared to be a relaxed position. All the cephalometric machines used had the same specifications. Radiographs that showed excessive straining of perioral soft tissue or severe lip incompetence were excluded from the study. The radiographs were of good quality, with soft tissue structures clearly discernible. All subjects in the study had four premolars extracted and were subsequently treated with edgewise fixed appliances. Subjects in the male and female groups were selected to show similarity in cephalometric parameters.

Cephalometric analysis

Pre- and posttreatment cephalometric tracings were superimposed by estimating a best fit of the anatomical structures of the floor of the anterior cranial fossa; primary consideration was given to the region between the anterior glenoid process and crista galli, as described by Baumrind.[2] Horizontal and vertical positional changes of certain landmarks were measured in relation to a Cartesian coordinate system. A constructed Frankfort horizontal plane (constructed by subtracting 7° from the sella-nasion line) served as the x-axis and a line perpendicular to it through sella served as the y-axis. To determine linear changes in the pre- and posttreatment tracings, the acetate was overlaid on a grid with a 1 mm

scale. Measurements were recorded to the nearest 0.5 mm.

To assess changes in upper incisor position, regional superimpositions were performed by estimating a best fit of the anterior maxillary structures with special attention to the anterior surfaces of the hard palate and the region between anterior nasal spine with the superior surfaces of the hard palate aligned.[2] Change in the mandibular incisor position was evaluated by creating an optimal fit of pre- and posttreatment images of the mandible with primary consideration given to the inner tables and trabecular anatomy of the symphysis and the lower anterior contour of the body of the mandible.[2]

Linear and angular measurements were also made on the pre- and posttreatment tracings, as shown in Figures 1 and 2.

Statistical analysis

The mean and the standard deviation for each cephalometric variable were determined. Two-tailed t-tests were used to determine the statistical significance of the changes in both the male and the female groups, as well as the difference between the two groups. Significance was assessed at $P<0.05$.

To determine the strength of the relationship between the cephalometric parameters, correlation coefficients for all possible variable combinations within each group were determined.

Measurement reliability

The combined error of tracing and measurement was determined by tracing 10 randomly selected cephalometric radiographs and by repeating the measurements. The initial mean and repeat mean values were compared for each cephalometric variable. Paired two-tailed t-tests were used to determine the statistical significance of the differences in mean value at $P<0.05$ level. In addition, correlation coefficients were calculated to determine the strength of the relationship between repeated measurements. The combined tracing and measurement errors were not significant at $P<0.05$.

Results

Changes during the treatment period are given in Tables 1, 2, and 3.

Upper lip

There was a significant increase in the nasolabial angle, both in males and females. There was 9.13° increase ($P<0.001$) in the male group, compared with 7.05° in females ($P<0.05$). The difference of 2.03° between the two groups was not significant (Figure 3). In males, upper lip thickness increased 2.67 mm ($P<0.001$); in females, the 0.53 mm increase was not significant.

When lip protrusion was measured to the subnasale-soft tissue pogonion line (Sn-Pg') as proposed by Burstone,[3] both groups showed a significant amount of upper lip retraction. The upper lip retracted 1.5 mm in males ($P<0.01$) and 1.74 mm in females ($P<0.01$). The difference between the two groups was not significant (Figure 4). However, when translation of the upper lip was determined by cranial base superimposition, in males labrale superior moved forward 1.37 mm, whereas in females it moved 1.5 mm backward (Figure 5). The difference between the two groups was highly significant ($P<0.001$).

Lower lip

The mean change of lower lip to subnasale-soft tissue pogonion was -2.7 mm for males ($P<0.01$) and -2.53 for females ($P<0.01$). The difference between the two groups was not significant (Figure 6). However, when translation of the lower lip was determined by cranial base superimposition, labrale inferior moved backward only 0.27 mm in males and 2.22 mm in females. The difference between the two groups was significant ($P<0.05$) (Figure 7). The increase in lower lip thickness and decrease in mentolabial angle were not significant.

Facial soft tissue

The tip of the nose moved forward 5.2 mm in males, but only 1.6 mm in females ($P<0.001$). In the vertical dimension, the tip of the nose moved downward 3.0 mm in males and 1.4 mm in females ($P<0.01$). Horizontal translation of soft tissue pogonion in males (3.5 mm) was approximately 10 times greater than the translation in females (0.3 mm). Vertically, soft tissue pogonion moved downward 6.6 mm in males and 2.9 mm in females. The difference between males and females was highly significant in both the horizontal and vertical dimensions ($P<0.001$).

Dentition

During treatment, upper incisor inclination in relation to constructed Frankfort horizontal decreased 12.5° in females ($P<0.001$) and 8.6° in males ($P<0.001$). The lower incisor uprighted approximately 8° ($P<0.001$) in both groups. As a result of incisor retraction, the interincisal angle increased 18.23° in males and 19.77° in females.

As determined by regional maxillary and mandibular superimpositions, the tip of the upper incisor crown retracted 4.15 mm in males and 5.48 mm in females. The tip of the lower incisor crown retracted 3.17 mm in males and 3.98 mm in females.

Table 1
Changes in the male group during treatment period (n =30)

Measurements	Pretreatment Mean	SD	Posttreatment Mean	SD	difference	Mean p value
Upper lip						
NLA (°)	92.3	15.4	101	12.6	9.1	<0.01
Upper lip length (mm)	25.4	2.5	26.5	2.4	1.1	NS
SnPg-upper lip (mm)	11.3	2.0	9.8	1.9	-1.5	<0.01
Upper sulcus thickness (mm)	14.1	1.7	14.9	2.3	0.8	<0.01
Upper lip thickness (mm)	15.4	2.9	18.1	2.6	2.7	<0.001
Lower lip						
MLS (°)	137.9	21.4	130.2	18.5	-7.7	NS
Lower lip length (mm)	32.1	3.9	33.5	4.6	1.5	NS
SnPg-lower lip (mm)	13.0	3.0	10.3	4.0	-2.7	<0.01
Lower lip thickness (mm)	18.8	2.2	19.4	2.3	0.6	NS
Lower sulcus thickness (mm)	13.7	1.6	13.0	1.4	-0.7	NS
Facial soft tissue						
GSnPg (°)	13.7	6.4	13.1	5.9	-0.6	NS
Interlabial gap	0.1	0.7	0.1	0.6	0.0	NS
Dentition						
Upper inc.- constr. FH (°)	121.3	7.0	113.0	8.1	-8.6	<0.001
IMPA (°)	104.7	7.1	96.7	9.4	-8.0	<0.001
Interincisal (°)	103.6	9.1	122	13.6	18.2	<0.001
Lower inc. - APo (mm)	8.0	2.3	4.4	2.8	-3.7	<0.001
Overjet (mm)	3.6	1.8	1.4	1.1	-2.1	<0.001
Overbite (mm)	2.8	1.7	2.1	1.3	-0.70	NS

Table 2
Changes in the female group during treatment period (n=30)

Measurements	Pretreatment Mean	SD	Posttreatment Mean	SD	difference	Mean p value
Upper lip						
NLA (°)	90.0	13.0	97.1	11.9	7.1	<0.05
Upper lip length (mm)	23.9	2.2	24.9	2.2	1.0	NS
SnPg-upper lip (mm)	9.8	2.4	8.1	2.5	-1.74	<0.01
Upper sulcus thickness (mm)	13.3	1.8	12.8	1.5	-0.5	NS
Upper lip thickness (mm)	14.1	2.3	1.6	2.7	0.5	NS
Lower lip						
MLS (°)	129.1	26.1	123.5	28.6	-5.5	NS
Lower lip length (mm)	27.8	4.0	29.5	4.8	1.7	NS
SnPg-lower lip (mm)	10.7	3.1	8.1	3.4	-2.5	<0.01
Lower lip thickness (mm)	17.6	2.7	17.3	2.9	-0.4	NS
Lower sulcus thickness (mm)	13.0	1.9	12.3	1.6	-0.6	NS
Facial soft tissue						
GSnPg (°)	13.0	5.5	12.6	4.4	-0.4	NS
Interlabial gap	1.0	1.9	0.2	0.5	-0.8	<0.05
Dental						
Upper inc.- constr. FH (°)	121.3	6.8	108.9	8.7	-12.4	<0.001
IMPA (°)	106.2	7.6	97.4	6.6	-8.8	<0.001
Interincisal (°)	101.5	8.5	121.8	10.4	20.3	<0.001
Lower inc. - APo (mm)	7.9	2.9	4.1	2.8	-3.9	<0.001
Overjet (mm)	3.2	1.8	1.3	1.2	-1.9	<0.001
Overbite (mm)	3.2	1.5	2.4	1.4	-0.8	<0.05

Table 3
Comparison of changes in the male and female group during treatment period

Measurements	Males (n=30) Mean	SD	Females (n=30) Mean	SD	Mean difference	p value
Upper lip						
NLA (deg)	9.1	12.8	7.1	7.8	2.0	NS
Upper lip length (mm)	1.1	1.9	1.0	1.5	0.16	NS
SnPg-upper lip (mm)	-1.5	1.4	-1.7	1.5	0.2	NS
Upper sulcus thickness (mm)	0.8	1.9	-0.5	1.4	1.3	<0.01
Upper lip thickness (mm)	2.7	2.5	0.5	2.0	2.1	<0.001
* Horiz.translation of labrale sup. (mm)	+1.4	3.6	-1.5	2.4	2.9	<0.001
* Vert. translation of labrale sup. (mm)	-4.6	3.0	-2.1	2.4	2.5	<0.001
Lower lip						
MLS (°)	-7.7	13.4	-5.5	12.3	2.2	NS
Lower lip lenghth (mm)	1.4	4.0	1.7	3.1	0.3	NS
SnPg-lower lip (mm)	-2.7	2.5	-2.5	2.1	0.2	NS
Lower lip thickness (mm)	0.6	2.3	-0.4	2.3	1.0	NS
Lower sulcus thickness (mm)	-0.7	1.2	-0.6	1.1	0.1	NS
* Horiz. translation of labrale inf. (mm)	-0.3	3.5	-2.3	3.0	2.0	<0.05
* Vert. translation of labrale inf. (mm)	-5.3	3.1	-2.1	3.4	3.2	<0.001
Facial soft tissue						
GSnPg (°)	-0.6	2.3	-0.4	2.1	0.2	NS
Interlabial gap	0.0	0.9	-0.8	1.8	0.8	<0.05
* Horiz. translation ofnose tip (mm)	+5.2	3.2	+1.6	1.7	3.6	<0.001
* Vert. translation of nose tip (mm)	-3.0	2.4	-1.4	2.2	1.6	<0.01
* Horiz. translation o Pg (mm)	+3.5	4.5	+0.3	2.2	3.2	<0.001
* Vert. translation of Pg (mm)	-6.6	3.9	-2.9	3.6	3.7	<0.001
Dentition						
Upper inc.-constr. FH (°)	-8.6	6.6	-12.4	7.5	3.9	<0.05
IMPA (°)	-8.0	8.5	-8.3	5.1	0.3	NS
Interincisal (°)	18.2	11.7	20.3	9.5	2.1	NS
Lower inc. - APo (mm)	-3.7	2.2	-3.9	1.9	0.2	NS
Overjet (mm)	-2.1	2.8	-1.9	1.8	0.2	NS
Overbite (mm)	-0.70	2.0	-0.8	1.6	0.1	NS
* Horiz. translation of upper inc. (mm)	-3.6	3.3	-5.3	2.1	1.7	<0.05
* Vert. translation of upper inc. (mm)	-4.2	2.6	-1.6	2.2	2.6	<0.001
* Horiz. translation of lower inc. (mm)	-2.2	3.3	-3.7	2.5	1.5	NS
* Vert. translation of lower inc. (mm)	-4.4	3.4	-2.1	2.4	2.3	<0.01

\+ Denotes upward or forward displacement of landmark
\- Denotes downward or backward displacement of landmark
* Determined by cranial base superimposition

Discussion

One of the major findings of this study was that, during treatment, upper and lower lip procumbency decreased in relation to the SnPg' line. The upper lip retracted about 1.5 mm ($P<0.01$) in both males and females. As determined by maxillary superimposition, the upper incisors retracted an average of 4.2 mm in males and 5.5 mm in females during treatment. This represents a ratio of upper lip retraction relative to SnPg' and upper incisor retraction as determined by maxillary superimposition of 1:2.8 for males and 1:3.2 for females. In other words, the upper lip retracted approximately 1 mm for every 3 mm of upper incisor retraction in males and females.

As determined by mandibular superimposition, the lower incisor retracted about 3.2 mm in males and 4 mm in females. The ratio of lower lip retraction relative to SnPg' and lower incisor

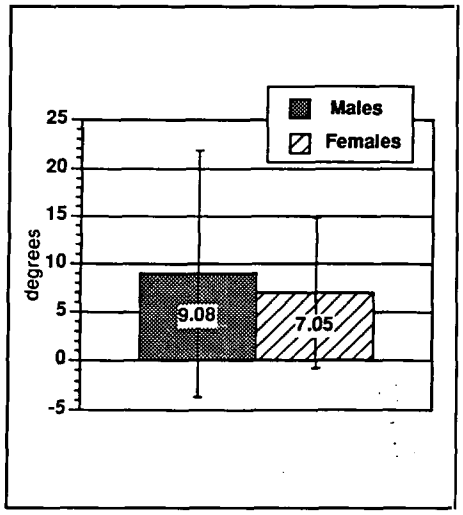

Figure 3

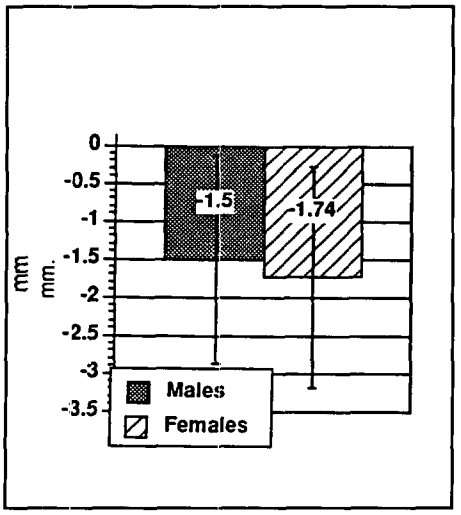

Figure 4

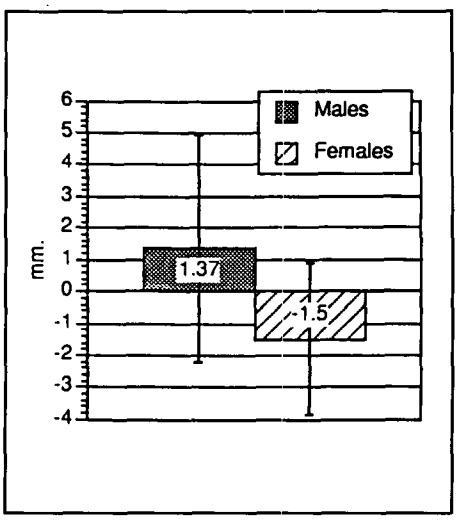

Figure 5

Figure 3
Change in nasolabial angle

Figure 4
Change in upper lip to SnPg' line

Figure 5
Horizontal translation of upper lip as determined by cranial base superimposition (- denotes backward movement).

Figure 6
Change in lower lip to SnPg' line

Figure 7
Horizontal translation of lower lip as determined by cranial base superimposition (- denotes backward movement).

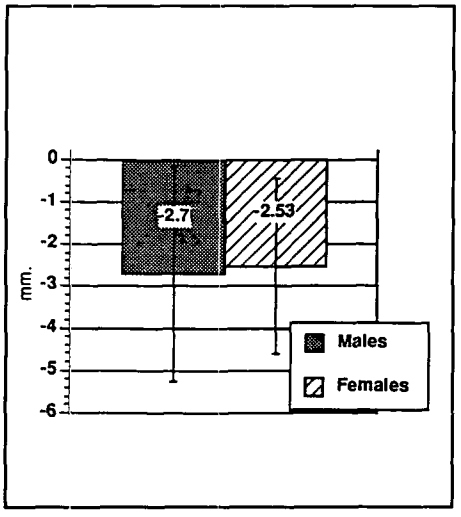

Figure 6

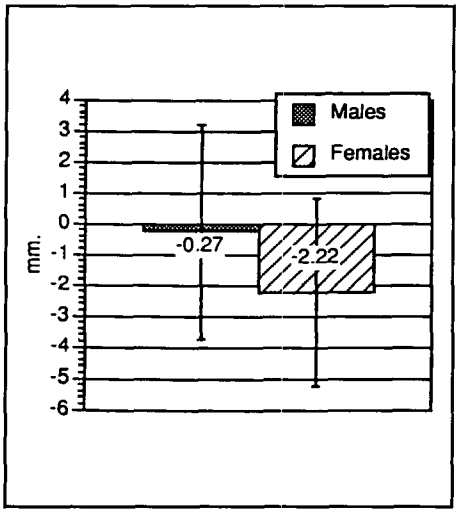

Figure 7

retraction as determined by mandibular superimposition was 1:1.2 for males and 1:1.6 for females. It must be remembered that the upper lip is generally in contact only with the upper anterior teeth and would, therefore, be influenced mostly by the retraction of the upper teeth. However, in bimaxillary protrusion, the lower lip most often contacts both the lower and upper incisors and would, therefore, be influenced not only by the retraction of the lower incisors but retraction of the upper incisors as well. In addition, one should take note that these ratios of lip retraction are based on the means of the sample. There is, however, a large standard deviation in these measurements, indicating large variation in individual response. Thus, ratios should be applied with caution in predicting individual response to treatment.

When the movement of the lips is measured by cranial base superimposition, different pictures are seen in males and females. The average age at the start of treatment was 13 years 7 months for females and 13 years 2 months for males, meaning facial growth had slowed down in females while males continued to grow rapidly. As a result, as measured by cranial base superimposition, upper lip at labrale superior showed a forward displacement of 1.5 mm in males during treatment despite the upper incisor retraction. Even though cranial base superimposition showed forward displacement of the upper lip in males, because subnasale and soft tissue pogonion continued to move forward with growth more than the lips, there was a relative retraction of the lips in relation to the SnPg' line. In females, on the other hand, because growth had slowed down, the upper lip, as measured by cranial base superimposition, showed 1.5 mm backward displacement due to incisal retraction during treatment. A similar difference in the amount of forward displacement also applied to the lower lip. The findings of this study are fairly

similar to those reported by Garner.[1] Based on a smaller sample of African-American patients, Garner reported 1.5 mm forward movement of the upper lip in males and 2.8 mm backward movement in females as determined by cranial base superimposition.

The amounts of lip and incisor movement were determined by cranial base superimposition and ratios of lip to incisor retraction were noted. Due to larger forward movement of the lips with growth in males, the ratios were found to be quite different in males and females. The ratio of upper lip retraction to upper incisor retraction in females was 1:3.3. However, the ratio in males was not relevant since the upper incisors moved backward due to treatment and the upper lip moved forward due to growth. Similar results were reported by Garner[1] in the male group. The ratio of lower lip retraction to lower incisor retraction as determined by cranial base superimposition was 1:1.6 in females. In males, as with the upper lip, the lower lip displaced forward due to growth but retracted due to treatment, so a ratio was not clinically relevant. Studies in Caucasians, based primarily on patients who have completed active growth, have reported ratios ranging from 1:1.6 to 1:3.8 for upper lip-to-upper incisor retraction and ranges from 1:0.6 to 1:1.2 for lower lip-to-lower incisor retraction. In this study, the ratio of lip- to-incisor retraction in African-American females was not very dissimilar to that found in Caucasians. As determined by cranial base superimposition in this study the ratios of lip-to-incisor retraction were quite different in males and females. The most likely cause of this is the difference in the amount of growth in the soft tissues in the two groups and not a difference in the nature of the soft tissues between males and females.

As a result of the retraction of the incisors and upper lip, there was a significant increase in the nasolabial angle. In males the nasolabial angle increased 9°, and in females 7°. Russel et al.[9] reported a slightly larger increase of 13.2° in nasolabial angle in their study. However, the amount of incisor retraction could account for the difference.

The findings of the present study indicate that in situations where decrease of lip procumbency is desirable, extraction of premolars and retraction of incisors is a viable option to achieve these objectives. One should, however, bear in mind that individual variation in response is large. Incisor retraction in one patient may lead to a large amount of lip retraction, whereas in another patient, a similar amount of retraction may lead to only minimal improvement in lip procumbency. It would, therefore, be prudent to inform the patient of average changes to expect, but to also inform the patient that in his or her particular instance this could be different. In addition, when a 13- or 14-year-old patient presents for treatment, and the main objective is to reduce the prominence of the lips, one should take the sex of the patient into consideration. In a male patient the nose and chin will continue to grow much more than in a female patient. This would have the effect of decreasing lip procumbency relative to the SnPg' line, and especially to a line drawn from the tip of the nose to the tip of the chin. In this study, during treatment, the tip of the nose moved forward 5.2 mm in males, but only 1.6 mm in females. Similarly, soft tissue pogonion moved forward 3.5 mm in males and only 0.3 mm in females. Although with growth, the prominence of the lips decreases relative to the nose and chin, the nasolabial angle does not

Figure 8A

Figure 8B

Figure 8A-B
A: Pretreatment cephalogram
B: Posttreatment cephalogram. Note retraction of lips in relation to SnPg' line, and increase in nasolabial angle.

change much.[3] Therefore, one should not expect a spontaneous improvement in the nasolabial angle without treatment.

The changes that were recorded in this study between the pretreatment and posttreatment cephalograms were a result of both treatment and growth. To isolate the effect of treatment, an adult sample could be studied. However, one must realize that most of the patients that are treated by orthodontists are growing patients. Therefore, it is important to determine the combined effect of treatment and growth. It would, however, be useful to have a longitudinal growth study of the soft tissue profile of African-Americans to estimate changes with growth.

Conclusions

Pre- and posttreatment cephalograms of 30 male and 30 female African-American patients were analyzed in order to determine the changes in soft tissue profile following orthodontic treatment. The mean age at the start of treatment was 13 years 2 months in males and 13 years 7 months in females. From this study, one can conclude that extraction of premolars and retraction of incisors in African-American adolescents with bimaxillary protrusion leads to the following changes:

1. Increase in the nasolabial angle, both in males and females.
2. Retraction of upper and lower lips relative to SnPg' line, both in males and females.
3. As determined by cranial base superimposition, in adolescent males the upper lip continues to move forward, despite retraction of the incisors.
4. The nose and chin show significantly more downward and forward growth in males than in females after the age of about 13 or 14 years.
5. There is large individual variation in soft tissue response to treatment.

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