The effect of premolar extractions on the soft-tissue profile in adult African American females

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Facial patterns and facial types differ significantly among various ethnic groups and races. Black Americans differ significantly from white Americans in dental, skeletal, and soft-tissue parameters. Numerous authors have characterized the African American soft-tissue profile and underlying hard-tissue structures of the teeth and alveolus as being more protrusive than European American norms.[1-5] Greater bimaxillary dentoalveolar protrusion results in protrusion of the lips and convexity of the face.

It is generally accepted that orthodontic treatment may influence the soft-tissue profile. Most clinicians agree that the extraction of four first premolars to create space to retract the incisors will bring about a reduction in facial convexity. The relationship of maxillary and mandibular incisor retraction and changes in the upper and lower lips has been described in numerous studies. Others have attempted to identify the important contributing factors responsible for these changes. However, the nature of the correlation between the two still remains controversial.

The current orthodontic literature can be categorized into two major schools of thought.[11] Some researchers have found a high degree of correlation between incisors and upper lip retraction, suggesting a close relationship between soft

Abstract

The present study was designed to evaluate the effect of four first premolar extractions on the soft tissue profile in African American patients. Pretreatment and posttreatment cephalograms of 28 adult female patients were assessed. The data were subjected to ANOVA, and correlation coefficients were performed between the significantly different dental and soft tissue variables. Variables that showed correlation at *r* value of greater then 0.6 were subjected to a stepwise multiple regression. The results of the study indicate that retraction of the lower lip correlates with retraction of both maxillary and mandibular anterior teeth. A ratio of 1.75:1 was obtained between mandibular incisor retraction and retraction of the lower lip. The relationship between the upper lip and retraction of maxillary incisors was not significant. A ratio of 1.2:1 was attained between maxillary incisor retraction and upper lip change. The upper lip correlated most strongly with lower lip retraction. Mandibular incisor angulation was the only hard-tissue variable that could be used as a predictor in a regression model to explain lip response to orthodontic therapy. Changes in the maxillary complex were more difficult to predict because of the complex nature of the soft-tissue integument and the details of muscle tension and soft-tissue tone that were lost by conversion of a three-dimensional structure into a roentgenographic cephalogram. A significant profile change did occur following the extraction of four first premolars and subsequent orthodontic therapy.

Key Words

African American • Bimaxillary protrusion • Extraction • Soft tissue profile

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Figure 1
Soft-tissue landmarks and reference planes.

Figure 2
Hard-tissue landmarks.

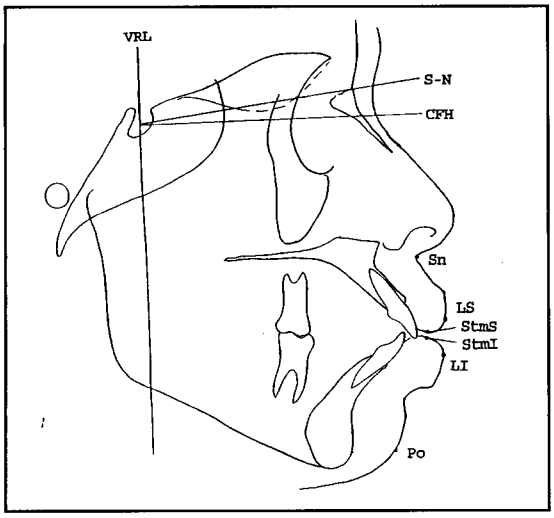

Figure 1

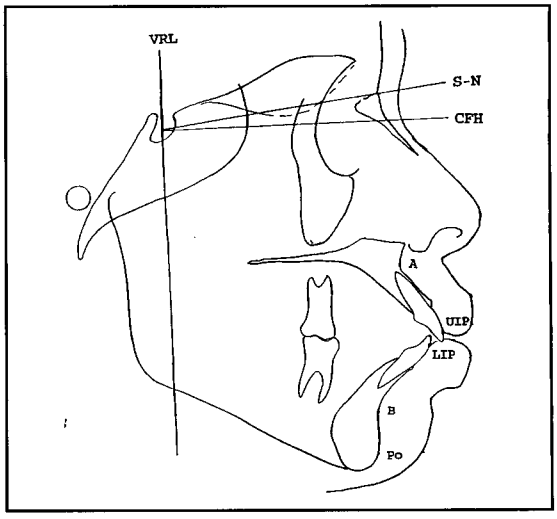

Figure 2

tissue and underlying hard tissue.[3,6-12,25] Others have found that a definite proportional change in the soft tissue does not necessarily follow changes in the dentition.[2,13-19]

Few of these investigations describe the effect of orthodontic retraction on African American profiles. Garner,[3] in his study of black children, found maxillary incisor retraction averaged 4.31 mm and mandibular incisor retraction averaged 1.38 mm. He established a ratio of 3.6:1 for upper lip response and approximately 1:1 for the lower lip but concluded that lip changes could not be predicted using existing (white) norms in the sagittal dimension. Russell and Nelson[20] studied soft-tissue changes in growing black American children who had four first premolars extracted. The results showed a generally insignificant amount of profile reduction as a result of orthodontic treatment. They concluded that growth was a significant factor in the evaluation of soft-tissue profile changes in the horizontal direction. In a study of vertical dimension changes in the lips in blacks, Park et al.[21] showed 3.87 mm of maxillary incisor retraction. Mandibular incisor retraction was found to be insignificant, negated by the masking effect of mandibular growth. They concluded that maxillary incisor retraction in blacks was directly related to the change in interlabial vertical dimension, but inversely related to changes in the inferomentolabial angle. Diels et al.[25] looked at profile changes in African American children and found that upper and lower lip procumbency decreased in relation to the SnPg' line, and that the nasolabial angle increased when four premolars were extracted.

An accurate determination of the effects of treatment on the integumental profile requires removal of the effects of growth. Very few studies in the literature have considered adults in their sample to determine profile changes associated with incisor retraction. Hershey[15] limited his sample to postadolescent white females. He did not find a good correlation between hard- and soft-tissue landmarks. Rains and Nanda[18] analyzed records of 30 postpubertal white females to determine the correlation between maxillary incisor retraction and integumental profile changes. They found a complex interaction between the dentition, the bony structures, and the perioral soft-tissue profile. Lew et al.,[12] in a study of Chinese Class I bimaxillary protrusive adults, demonstrated a definite association between incisor retraction and soft-tissue response.

Few studies have considered whether the profile has been "improved" by extraction treatment. Drobocky and Smith[22] examined 160 orthodontic patients treated with removal of four first premolars and concluded that 80% to 90% of the patients had soft-tissue measurements that suggested the profile either improved or remained satisfactory throughout treatment (based on standards developed for white Americans). Farrow et al.[23] expanded upon the work of other authors to determine that black Americans preferred a "slightly convex" profile, which is somewhat straighter than what has been determined to be normal for blacks. Polk et al.[26] using profile silhouettes revealed that African Americans found the flatter profile silhouettes more pleasing but preferred fuller lips than are typical for white profiles.

The purpose of this investigation was to examine the effect of extraction of four first premolars on the perioral soft tissue in adult black Americans exhibiting a bimaxillary protrusive profile. Another objective was to determine if extractions were indicated to "improve" the profile in blacks as de-

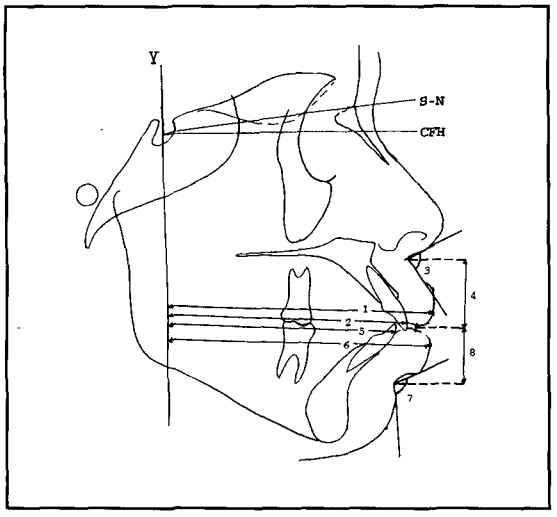

Figure 3

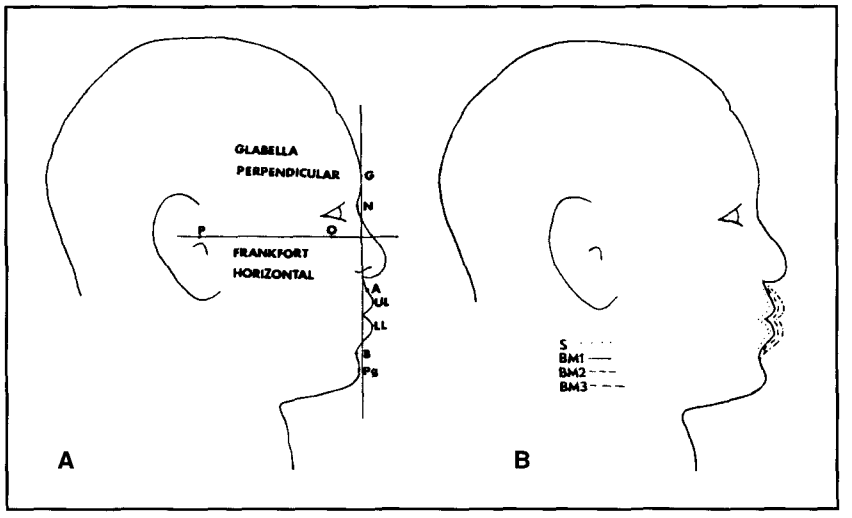

Figure 4

termined by the method described by Farrow et al.

Materials and methods

Sample

Retrospective data were obtained from pre- and posttreatment lateral cephalometric radiographs for 28 patients who met the following criteria: (1) Adult black American females (range 15 to 34 years, median 22.5 years at beginning of treatment); (2) Presenting with a bimaxillary protrusive profile as determined by clinical soft tissue profile assessment; (3) Treated with four first premolar extraction based on the chief complaint of the patient and the soft tissue profile; (4) Edgewise mechanics were employed to close space and retract incisors within a range of moderate to maximum anchorage. At least 3 mm of mandibular incisor retraction was necessary to be included in the study. Treatment time averaged 36 months.

Radiographs

Lateral cephalograms were taken with Frankfort horizontal parallel to the floor. Soft tissues were subjectively judged to be in repose. The pre- and posttreatment cephalograms were also ruled out for enlargement and distortion between pairs by comparing the length and morphology of cranial base structures. Therefore, the locations of sella and nasion were consistent between the pre- and posttreatment radiographs.

Cephalometric analysis

Pre- and posttreatment lateral cephalograms were traced on standard acetate paper with a mechanical pencil using 0.5 mm lead. Each pair of patient radiographs was traced at the same sitting to minimize tracing error. Landmarks and reference lines used in the study are depicted in Figures 1 and 2. A horizontal reference line (CFH) constructed 7° inferior to sella-nasion was used as the x-axis. A vertical reference line (Y) passing through sella and perpendicular to the x-axis served as the y-axis. All measurements were taken to the nearest 0.5 mm or 0.5°. Besides sella, nasion, pogonion, point A, and point B, the following less familiar dental and soft tissue points were identified for the study (Figures 1 and 2).

Subnasale (Sn)-The point of convergence of the nose and upper lip.

Superior sulcus (SS)-The point of greatest concavity in the midline between upper lip (LS) and subnasale (Sn).

Labrale superius (LS)-The most anterior point on the convexity of the upper lip.

Labrale inferius (LI)-The most anterior point on the convexity of the lower lip.

Sulcus inferius (SI)-The point of greatest concavity in the midline between the lower lip and soft tissue chin.

Soft tissue pogonion (Po')-the most anterior point on the soft tissue chin.

Stomion superius (StmS)-the lowermost point of the upper lip.

Stomion inferius (StmI)-the uppermost point on the vermillion border of the lower lip.

Upper incisor (U1)-the most anterior point on the crown of the maxillary incisor.

Lower incisor (L1)-the most anterior point on the crown of the mandibular incisor.

Linear measurements were made from the above listed hard- and soft-tissue points to the y-reference plane, or to each other (Figure 3). The degree of protrusion was measured by the method described by Farrow et al. (Figure 4).

Measurement reliability

Method reliability was determined by retracing and remeasuring five randomly selected pairs of

Figure 3
Linear and angular measurements identified in Table 2.

Figure 4
A. Reference planes and soft-tissue landmarks (UL, LL) used to measure degree of protrusion.
B. Lateral profile sketch showing horizontal lip positions associated with each profile type (from Farrow et al., 1993).

Table 1
Mean changes in skeletal landmarks due to treatment

Variable	Mean change Pre /post	SD	p<.05
SNA °	0.09	1.12	N.S.
SNB °	0.21	0.88	N.S.
ANB °	0.23	1.18	N.S.
FMA °	0.38	1.95	N.S.
A-Y mm	0.19	1.05	N.S.
B-Y mm	0.5	1.43	N.S.

Table 2
Dental and soft tissue changes due to mechanotherapy

Ref No.* Variable	Ceph. point	Mean Pre/post	SD	SEM	P-value
1 Upper lip retraction	LS-Y	3.23 mm	1.75	0.332	<0.01
2 Upper incisor retraction	U1-Y	5.58mm	1.76	0.333	<0.001
3 Nasolabial angle	NLA	9.39°	8.6	1.630	<0.05
4 Upper lip length	Sn-StmS	0.37 mm	1.79	0.339	NS
Upper lip thickness	U1-LS	2.00 mm	2.69	0.509	<0.01
5 Lower incisor retraction	L1-Y	5.64 mm	1.88	0.356	<0.001
6 Lower lip retraction	LI-Y	4.54 mm	2.21	0.418	<0.01
7 Labiomental angle	LMF	1.25°	12.39	2.340	NS
8 Lower lip length	SI-StmI	0.39 mm	1.52	0.287	NS
Lower lip thickness	L1-LI	1.05 mm	1.66	0.315	<0.05

*Refer to Figure 3 for diagram of measurements.

Table 3
Correlation coefficients (r) for comparison of selected hard- and soft-tissue changes

Soft tissue	Hard tissue	r
Upper lip retraction (LS-Y)	Upper incisor retraction (U1-Y)	0.417
Upper lip retraction	Lower incisor retraction (L1-Y)	0.350
Nasolabial angle (NLA)	Upper incisor retraction	0.330
Lower lip retraction (LI-Y)	Upper incisor retraction	0.683*
Lower lip retraction	Lower incisor retraction	0.675*
Labiomental fold (LMF)	Lower incisor retraction	0.321
Upper lip thickness (U1-LS)	Upper incisor retraction	0.136
Lower lip thickness (L1-LI)	Lower incisor retraction	0.219
Upper lip retraction	Lower lip retraction	0.629*

* indicates correlation strong enough to be subject to stepwise multiple regression.

cephalograms. A second observer then repeated the tracings and measurements to obtain interjudge reliability. A Student's *t*-test measuring the reliability of the landmark selection, and a measuring process between operators showed no significant difference at the level of P≤0.05. Pearson *r* correlation coefficient indicated a high correlation between the values obtained by the same operator (r =0.82).

Statistical analysis

The mean and standard deviations of the differences between pre- and posttreatment for each of the hard- and soft-tissue measurements were calculated. These means measure the effect of treatment mechanotherapy. The means for each variable were subjected to ANOVA to determine the significance of change between pre- and posttreatment. This data was then subjected to Pearson *r* correlation analysis, which calculated the correlation coefficient between each pair of the significant variables used in the study. A stepwise multiple regression analysis (forward) was performed for each of the significant soft tissue measurements investigated. The purpose was to identify the effect of the most important independent variables on the significant dependent variables at the level of significance P≤0.05.

Results

Tables 1 and 2 list descriptive statistics summarizing the changes in hard and soft tissue landmarks with treatment. A test of analysis of variance between data obtained from pre- and posttreatment cephalograms indicated seven soft-tissue and dental variables had statistically significant differences at P≤0.05. The interpretation of Tables 1 and 2 led to the following conclusions: (1) minimal changes in skeletal landmarks indicated growth was not a factor; (2) significant retraction of the upper and lower lip occurred with treatment (Figure 3); (3) the nasolabial angle became more obtuse with treatment (however, the labiomental angle was not significantly affected); (4) the length of the upper and lower lips remained essentially unchanged; and (5) the upper and lower lips thickened with treatment. The mean treatment changes are shown diagramatically in Figure 5. The dental and soft- tissue variables that showed significant difference between pre- and posttreatment groups were subjected to a correlation analysis. A Pearson *r* value of 0.60 or greater was indicative of correlation. The relationship of the soft-tissue and dental variables is summarized in Table 3.

Lower lip

The mandibular incisor had a direct effect on the retraction of the lower lip (r=.675). Mandibular incisor retraction of 5.62±1.88 mm caused the lower lip to retract by an average of 4.54±2.2 mm,

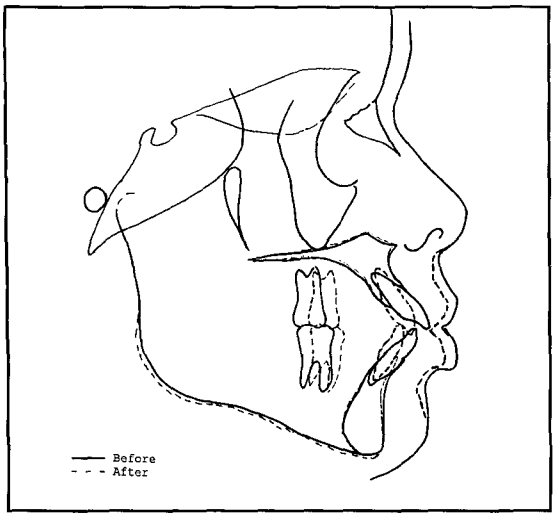

Figure 5

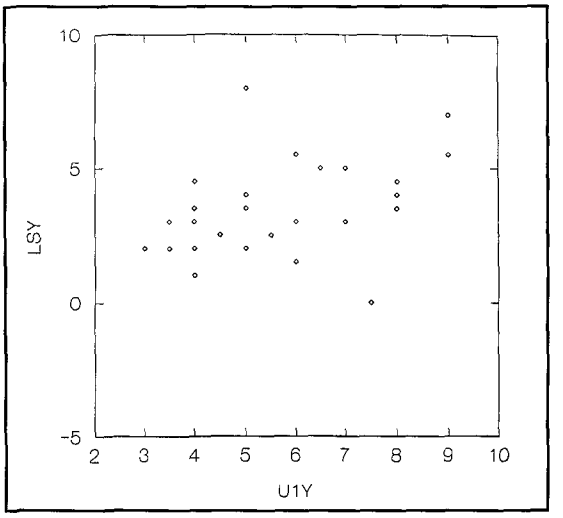

Figure 6

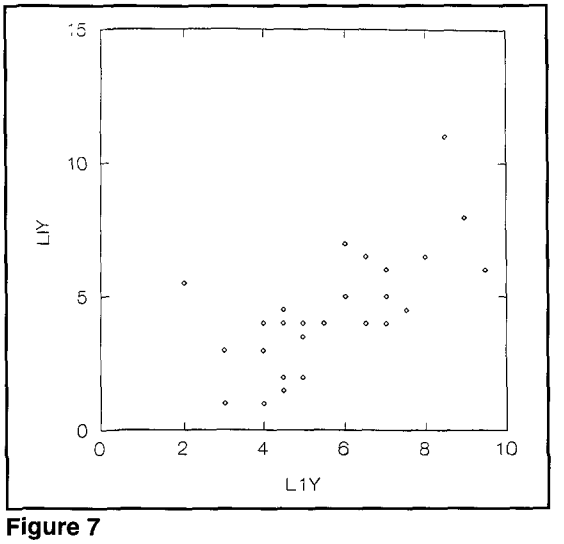

Figure 7

Figure 5
Superimposed pre- and posttreatment cephalometric tracings of a typical case.

Figure 6
Response of the upper lip to retraction of the maxillary incisors.

Figure 7
Response of the lower lip to retraction of the mandibular incisors.

giving a ratio of 1.2:1. The results of the stepwise multiple regression indicated that greater lower lip retraction seemed to take place with increased mandibular incisor retraction and increased upper lip retraction. These factors explain 70.1% (r^2=.701) of the variability in lower lip response, suggesting a significant prediction equation.

Upper lip

The present investigation showed that orthodontic treatment, including an average retraction of maxillary incisors of 5.59±1.76 mm, caused the upper lip to retract by an average of 3.44±1.75 mm, giving a ratio of 1.75:1. Analysis of correlation coefficients demonstrated a weaker correlation (r=.417) between retraction of the maxillary incisor and retraction of upper lip than previous reports. When the independent variables were entered stepwise into the regression analysis, the change in the lower lip position was accepted into the model (P≤.05). This factor explains only 42% of the variability in the upper lip response, which means that the prediction of the upper lip retraction is not reliable. All other soft-tissue variables showing significant change during treatment did not produce good correlations or predicable regression models.

Discussion

Careful selection of patients for the present study substantially reduced many of the variables that may have adversely affected the results of earlier studies. By limiting the sample to adult black females exhibiting a bimaxillary protrusive profile, the influence of growth and possible differences in responses between sexes was significantly reduced. Few investigators have separated the effects of treatment from growth. Russell and Nelson[20] and Park et al.[21] reported that the relationship of soft-tissue reference points could not be shown to be directly affected by retraction of the incisors because of the masking effect of growth. According to Deils et al.,[25] the amount of upper lip displacement as measured by cranial base superimposition in their sample of males demonstrated a forward displacement despite the maxillary incisor retraction. In their female sample, incisor retraction resulted in a backward displacement of the upper lip. They concluded that the likely difference in ratios of lip-to-incisor retraction was the difference in the amount of growth in the soft tissues rather than a difference between males and females. In agreement with previous studies, the present investigation showed that orthodontic treatment with incisor retraction causes lip retraction, but individual variation in response is large. The scatter diagrams, Figures 6 and 7, illustrate the wide variability of soft-tissue response that may occur with hard-tissue movement. A comparison of Figures 6 and 7 demonstrates that the upper

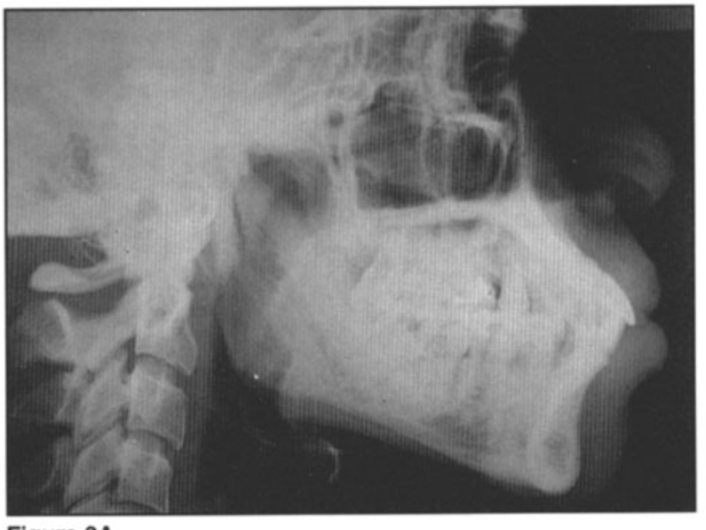

Figure 8A

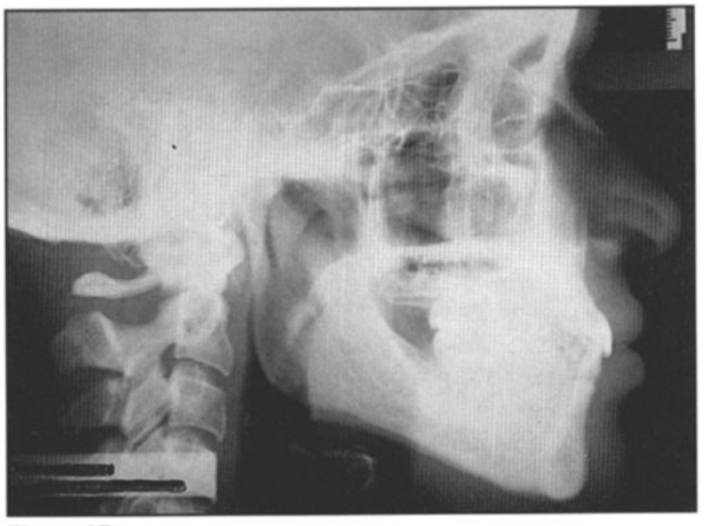

Figure 8B

Figure 8A-B
Pretreatment (A) and posttreatment (B) lateral cephalograms showing significant reduction in protrusion associated with extraction of four first premolars.

lip is more variable than the lower lip to differences in incisor retraction.

The lower lip showed higher correlations to maxillary and mandibular incisor retraction (r=.683 and r=.675, respectively) than previous studies. This may be due to insignificant amounts of mandibular incisor retraction reported by previous authors.

When a stepwise multiple regression analysis was performed to see if any independent variables showing a good correlation could be used to form a model of prediction, the only significant model that could be generated was the effect of the mandibular incisor on the lower lip (mult r=.701). Talass et al.[19] reported similar findings, that changes in the lower lip in response to orthodontic tooth movement were more predictable than those of the upper lip.

Intuitively, one would assume a direct cause-and-effect relationship of dentition retraction to soft-tissue retraction. The response of the lower lip to mandibular incisor movement in this sample seems to support this statement. In contrast, lack of correlation between the retraction of the upper lip in response to maxillary incisor retraction (r=.417) questions this relationship. On the other hand, a higher correlation (r=.629) between the upper and lower lips suggests that the soft-tissue structures of the lips tend to support each other. This is consistent with the findings of Burstone[2] and Hershey,[15] who proposed that the perioral soft tissue may be self-supporting and that factors other than dental movement may cause the wide variability in individual response to treatment. This study also agreed with Talass et al.,[19] who found that many factors dictate the amount of upper lip retraction, and that the prediction of upper lip retraction is not reliable.

Other authors investigating Caucasian[18] and Asian[15] samples have found a higher degree of correlation between lip response and incisor retraction. The present study could neither support nor refute those prediction models already proposed. The low degree of predictability of upper lip response to orthodontic tooth movement in this sample may be attributed to the complex three-dimensional anatomy of the upper lip-nose complex that cannot be well analyzed on an image such as a cephalogram. Oliver[11] implied that maxillary lip thickness and postural tone might play a role in predicting soft tissue changes sub-

sequent to orthodontic retraction of the maxillary incisors. The influence of body fat on lip thickness might also be a factor in lip response.[24] Statistical assessment of this postulate was beyond the scope of the present investigation, but warrants further investigation in a larger black sample.

The reduction of bimaxillary protrusion of the upper and lower lip as measured to glabella perpendicular (x=-3.5 mm) was significant. Farrow et al.[23] used 3 mm reduction increments to describe their profile types as S, BM1, BM2, and BM3 (Figure 4). They found that black Americans prefer a flatter profile (BM1) than what has been measured as normal (BM2). From the present study it can be extrapolated that a mean reduction of 3.5 mm of lip protrusion resulting from the extraction of four first premolars will cause an improvement in profile (i.e. BM2>BM1) in a significant number of treated cases. However, the basis for extraction as a guarantee of improvement in soft-tissue profile cannot be made. It can be used to support an extraction therapy approach in conjunction with other determining factors, such as crowding, periodontal support, functional occlusal needs, and the patient's desire for dental protrusion reduction.

Conclusions

The descriptive statistics, tests of significance, correlation coefficients and multiple regression analysis justify the following statements:

1. Retraction of the mandibular incisor correlates with lower lip retraction, indicating that mandibular incisor change can be used, in part, as a predictive model for change in the lower lip
2. The inability to formulate any other strong correlations between hard and soft tissues, as well as regression models, indicates that the change in the perioral soft tissue is a complex phenomenon and many factors play roles in its reduction.
3. Although it is difficult to predict exactly how the variables interact, significant profile changes were observed following the extraction of four premolars in this sample.
4. Given similar inclusion criteria, the extraction of four first premolars will result in an "improvement" in the profile in a significant number of African Americans desiring a less protrusive profile.
5. Considering the variability in results from the regression analysis, a larger sample size should be evaluated to confirm or refute some of the trends.
6. Although the present study reports still another ratio, it is with the emphasis that the direct cause-and-effect relationship that ratios assume are only valuable in the broadest sense and may have very little value when applied to an individual subject.

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References

1. Altemus LA. Comparative integumental relationships. Angle Orthod 1963;33:217-21
2. Burstone CJ. Integumental contour and extension patterns. Angle Orthod 1959;29:93-104.
3. Garner LD. Soft-tissue changes concurrent with orthodontic tooth movement. Am J Orthod 1974;64:367-77.
4. Fonseca RJ, Klein DW. A cephalometric evaluation of American Negro women. Am J Orthod 1978;73:152-60.
5. Sushner NI. A photographic study of the soft tissue profile in North American black women. Am J Orthod 1977;72:373-85.
6. Stoner MM, Lindquist JT. A cephalometric evaluation of 57 cases treated by Dr. C.H. Tweed. Angle Orthod 1956;26:68-98.
7. Riedel RA. An analysis of dentofacial relationships. Am J Orthod 1957;43:103-19.
8. Bloom L. Perioral profile changes in orthodontic treatment. Am J Orthod 1961;47:371-9.
9. Rudee DA. Proportional profile changes concurrent with orthodontic therapy. Am J Orthod 1964;50:421-34.
10. Roos N. Soft tissue profile changes in Class II treatment. Am J Orthod 1977;72:165-75.
11. Oliver BM. The influence of lip posture and strain on upper lip response to incisor retraction. Am J Orthod 1982;82:141-149.
12. Lew K. Profile changes following orthodontic treatment of bimaxillary protrusion in adults with the Begg appliance. Eur J Orthod 1989;11:375-81.
13. Neger MA. A quantitative method for the evaluation of the soft tissue profile. Am J Orthod 1959;45:738-51.
14. Subtelny JD. The soft tissue profile, growth and treatment changes. Angle Orthod 1961;31:105-22.
15. Hershey HG. Incisor tooth retraction and subsequent profile changes in post-adolescent female patients. Am J Orthod 1972;61:45-51.
16. Angelle PL. A cephalometric study of the soft-tissue changes during and after orthodontic treatment. Trans Eur Orthod Soc 1973:pp. 267-80.
17. Wisth PJ. Soft tissue response to upper incisor retraction in boys. British J Orthod 1974;1:199-204.
18. Rains MD, Nanda R. Soft tissue changes associated with maxillary incisor retraction. Am J Orthod 1982;74:396-404.
19. Talass MF, Talass L, Baker RC. Soft tissue profile changes resulting from retraction of maxillary incisors. Am J Orthod Dentofac Orthop 1987;91:385-94.
20. Russell DM, Nelson RT. Facial soft tissue profile change in the North American black with four first premolar extractions. J Md State Dental Assoc 1986;29(1):24-8.
21. Park S, Kudlick EM, Abrahamian A. Vertical dimension changes of the lips in the North American black patient after four first-premolar extraction. Am J Orthod Dentofac Orthop 1989;96:152-60.
22. Drobocky OB, Smith RJ. Changes in facial profile during orthodontic treatment with extraction of four first premolars. Am J Orthod Dentofac Orthop 1989;95:220-30.
23. Farrow AL, Zarrinnia K, Azizi K. Bimaxillary protrusion in black Americans-an esthetic evaluation and the treatment considerations. Am J Orthod Dentofac Orthop 1993;104:240-50.
24. Riolo, ML. Personal communication, 1994.
25. Deils RM, Kalra V, Deloach N, Powers M, Nelson SS. Changes in soft tissue profile of African Americans following extraction treatment. Angle Orthod 1995;65(4):285-292.
26. Polk MS, Farman AG, Yancey JA, Gholston LR, Johnson BE. Soft tissue profile: A survey of African American preference. Am J Orthod Dentofac Orthop 1995;108:90-103.