ORIGINAL ARTICLE

Ethnic differences in upper lip response to incisor retraction

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Introduction: The purpose of this retrospective longitudinal study was to investigate the response of the upper lip to incisor retraction and to ascertain the effect of ethnicity on this response. **Methods:** Pretreatment and posttreatment lateral cephalograms of 88 postpubertal female patients (44 black and 44 white; mean age, 18.45 years) were evaluated. The groups were matched by age and the amount of incisor retraction at incisor superius. **Results:** Although significant pretreatment differences existed between the groups in some cephalometric measurements, analysis of the treatment changes demonstrated significant differences only in incisor inclination. Hard and soft tissue changes of the black group were more downward, whereas changes in the white group were more backward. Multivariate regression analysis showed that the horizontal response of the upper lip to hard tissue changes at subnasale and superior labial sulcus was different in whites than in blacks. At subnasale, stepwise multivariate regression analysis showed that ethnicity contributed to the upper lip response to incisor retraction and was significantly greater in the white group. **Conclusions:** The hard and soft tissue treatment changes of the black group were more downward, and those of the white group were more backward. Ethnic differences exist in the soft tissue response to hard tissue changes in the upper lip, and at subnasale and the superior labial sulcus; however, these response differences at superior labial sulcus can be explained by the ethnic differences in initial lip thickness and incisor inclination; they are not due in and of themselves to ethnicity. The change at prosthion was significantly correlated with the response of the upper lip at labrale superius to incisor retraction. Ethnicity added no increase to the predictability of the response. When incisor retraction was performed, the final horizontal upper lip position could be accurately and reliably predicted. (Am J Orthod Dentofacial Orthop 2005;127:683-91)

The soft tissue of the face is a mask overlying a skeletal framework that is affected by dental and osseous changes. It is variably influenced by the amount, direction, and location of forces acting on the underlying hard tissues.[1,2] Hard tissue changes in the perioral region can affect the lip, nose, and chin areas.[3] Such hard tissue changes can be produced by surgical intervention, growth, orthopedic forces, and orthodontic movement of the teeth.[4,5] Changing the inclination and position of the teeth, either by protraction or retraction, directly influences the overlying soft tissue, particularly the lips.[6-16] Prediction of upper lip movement in response to tooth movement has commonly been expressed as the ratio of maxillary incisor retraction to upper lip retraction, but reports of this ratio have varied considerably according to sex, treatment modality, and ethnicity (Table I).[7,9,12,14,17-23] The upper lip changes both horizontally and vertically with incisor retraction, but these changes are incompletely explained by lip thickness, lip tonicity, initial incisor inclination, lip length, and lower lip proximity.

Ethnic differences in soft tissue composition and morphology could also influence upper lip response to incisor retraction. Many studies show significant differences between black and white subjects regarding adipose tissue distribution and amount, skin thickness and flexibility, and muscle density and weight.[24-30] In addition, black cephalometric data show significant differences between normal hard and soft tissue values compared with white subjects.[31-33] Blacks have greater incisor inclination and a more protrusive soft tissue profile.[34-36] A protrusive profile is more readily accepted in the black population, as evidenced by profile and esthetic line comparisons.[37-41] Because of significant hard and soft tissue differences between black and white subjects, it is possible that other differences exist regarding soft tissue response characteristics.[12,14,20,21]

This study was designed to evaluate whether there are ethnic differences in the upper lip response to incisor retraction. By using a sample of postpubertal black and

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Table I. Summary of existing literature on horizontal upper lip response to incisor retraction*

Race/Ethnicity	*Movement*	*Landmarks*	*Study*	*T1 age (years)*	*N*
NR	2:1	Ia:Ls	Rudee[17]	6-22	85
White	3:1 (female)	Ia:Ls	Hershey[7]	>16	36
Black	3.7:1 (combined) 2:1 (female only)	Is:Ls	Garner[18]	11-15	16
NR	2:1 (nonextraction) 3:1 (extraction)	Is:Ls	Wisth[9]	11-12	60 (male)
White	1.6:1 (female)	Ia:Ls	Rains[12]	15-23	30
White	1.6:1 (female)	Is:Ls	Talass[14]	10-18+	80
Asian	2.5:1 (female)	Is:Ls	Yogosawa[23]	Adult	20
Asian	2.1:1 (combined)		Lew[19]	22 (mean)	16
Black	3.2:1 (female) 2.8:1 (male)	Is:Ls	Diels[20]	10-17	60
Black	1.6:1 (female)	Ia:Ls	Caplan[21]	15-34	28
White	1.5:1 (female) 1.6:1 (male)	Is:Ls	Kokodynski[22]	>16	60

NR, Not reported.
*Computed from reported mean incisor retraction and mean upper lip retraction values.

Table II. Sample size, skeletal pattern, and extraction pattern

		Skeletal pattern			*Maxillary extraction pattern*		
	N	*Class I*	*Class II*	*Class III*	*First premolars*	*Second premolars*	*Asymmetric*
Black	44	26	16	2	36	5	3
White	44	21	21	2	41	2	1

white female patients, the purposes were to (1) evaluate the ethnic differences in upper lip thickness, upper lip length, and maxillary incisor inclination; (2) evaluate upper lip changes during treatment; (3) evaluate ethnic differences in the response of the soft tissue during treatment; (4) and determine the treatment variables that best predict the treatment response of the upper lip.

MATERIAL AND METHODS

Selection criteria

This longitudinal retrospective study evaluated the hard and soft tissues of postpubertal black and white females, chosen to reduce variation due to sex and age. The 2 groups were obtained from the pretreatment (T1) and posttreatment (T2) cephalograms of patients from the practices of 2 private practitioners and the Department of Orthodontics, Baylor College of Dentistry. Both samples were selected based on the following criteria:

1. Female patients >14 years of age at T1
2. Extraction of 2 maxillary premolars bilaterally
3. No syndromes or congenitally missing teeth
4. No orthognathic surgery
5. No radiographs with poor midfacial soft tissue resolution

The final sample of 88 postpubertal patients included 44 blacks and 44 whites (Table II). The black sample was case-matched to the white sample by chronological age (±12 months) and amount of incisor retraction (±1.5 mm), as measured by the horizontal change in incisor tip position from T1 to T2 before magnification correction. The median pretreatment age for the black (range, 14.1-37.8 years) and white (range, 14.1-37.7 years) groups was 16.4. The black group was treated for 3.5 ± 0.22 years and the white group for 2.7 ± 0.14 years, a significant difference ($P < .01$) of approximately 9 months. The ANB angle was used to categorize the skeletal pattern of each patient as Class I (ANB 0° to 4°), Class II (ANB > 4°), or Class III (ANB < 0°).

Cephalometric procedures and measurements

For each patient, pretreatment and posttreatment cephalograms were traced by the primary investigator (R.A.B.). The magnification of each cephalometer was known, and the appropriate magnification corrections were performed for each subject during data entry. Twenty hard tissue, soft tissue, and constructed cephalometric landmarks were identified and digitized (Table III, Fig 1): 8 hard tissue landmarks, 5 soft tissue landmarks, and 7 midlip landmarks. As identified and used in previous studies,[42,43] midlip landmarks were constructed to

Table III. Hard tissue, soft tissue, and constructed landmarks identified with associated method errors, calculated on 15 replicates

Hard tissue landmarks		*Explanation*	*Method error*	
			(H)	*(V)*
S	Sella	Center of pituitary fossa of sphenoid bone. Determined by inspection	NR	NR
N	Nasion	Most anterior point of nasofrontal suture on midsagittal plane	NR	NR
ANS	Anterior nasal spine	Most anterior point of nasal floor; tip of maxilla on midsagittal plane	0.36	0.27
A	Subspinale	Most posterior point in concavity between ANS and prosthion	0.28	0.58
Pro	Prosthion	Point where maxillary dental alveolus contacts labial surface of maxillary central incisors in midsagittal plane	0.35	0.28
Ia	Incisor anterius	Most prominent point on maxillary incisor as determined by tangent to incisor passing through subspinale	0.77	0.65
UIA	Upper incisor apex	Tip of root of most anterior maxillary incisor	0.44	0.44
Is	Incisor superius	Incisal edge of crown of most anterior maxillary incisor	1.16	0.42
Soft tissue landmarks				
Sn	Subnasale	Point at which nasal septum merges with upper cutaneous lip in midsagittal plane	0.45	0.43
SLS	Superior labial sulcus	Most posterior point in concavity between labrale superiorus and subnasale	0.45	0.69
LS	Labrale superius	Most anterior point of upper lip	0.72	0.42
STOs	Stomion upper lip	Most inferior point of upper lip at stomion	1.11	0.28
STOi	Stomion lower lip	Most superior point of lower lip at stomion	1.03	0.28
Constructed landmarks				
UL100	Midlip 100	Midpoint of segment ANS-Sn	0.30	0.29
UL75	Midlip 75	Midpoint of segment A-SLS	0.28	0.46
UL50	Midlip 50	Midpoint of segment UL75-UL25	0.35	0.24
UL25	Midlip 25	Midpoint of segment Pro-LS	0.49	0.26
UL0	Midlip 0	Point located at junction of line UL100-UL0 and line of lower border of upper lip	0.87	0.33
Mid LS		Midpoint of segment Ia-Ls	NR	NR
Z Point		Midpoint of line UL100-UL0	NR	NR

NR, Not reported.

better evaluate the gradient of change of the upper lip and the corresponding hard tissue (Fig 2).

Eight linear measurements of upper lip length, taper, and thickness (Table IV, Fig 3) were computed. In addition, 32 horizontal and vertical cephalometric measurements were computed from constructed horizontal and vertical axes. The horizontal axis was registered on sella and oriented 7° inferior to the sella-nasion line. The vertical axis was constructed through sella perpendicular to the horizontal axis. Superimpositions of the pretreatment and posttreatment cephalograms were performed on stable cranial base structures.[44]

To establish technical reliability, duplicate tracings of 15 randomly selected cephalograms were digitized. Mean differences were compared with their respective standard errors to establish systematic error. Systematic error was not statistically significant. Random error, ranging between 0.24 and 1.16 mm, was greatest for point incisor superius (Table III).

Statistical analysis

Statistical evaluations were performed with SPSS 10.0 (SPSS, Chicago, Ill). The normality of each distribution was verified by using skewness and kurtosis statistics. Means and standard deviations were used to describe the differences in the treatment changes of the hard tissue, outer lip, and midlip between the groups at T1 and T2. Multivariate regression analysis was used to (1) identify the relationship between soft tissue changes and the corresponding hard tissue changes, (2) evaluate group differences in the relationships between hard and soft tissue changes, and (3) determine the treatment variables that best predicted the treatment response of the upper lip to incisor retraction.

RESULTS

There were significant pretreatment differences between blacks and whites in lip length, lip thickness, and incisor proclination (Table V). Outer lip length and midlip length were approximately 2 mm greater in blacks. Upper lip thickness (ULT) at ULT1, ULT2, and ULT3 was approximately 1.5 mm greater in blacks. The incisors were approximately 7° to 10° more proclined in blacks than in whites.

There were no group differences in the treatment changes in lip length and lip thickness, but there were statistically significant differences between groups in change of maxillary incisor inclination with treatment

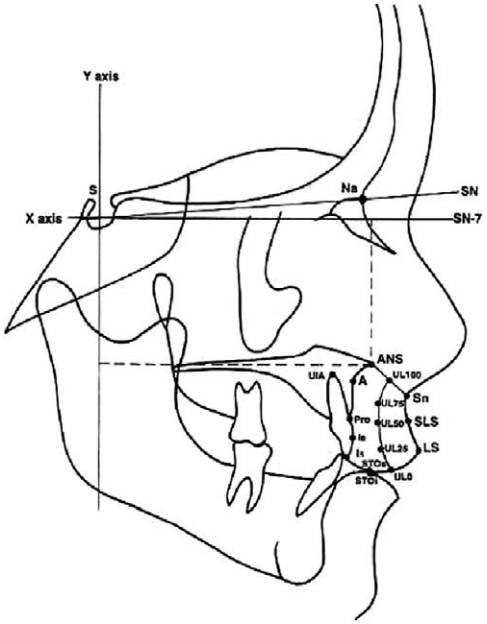

Fig 1. Cephalometric landmarks and reference lines.

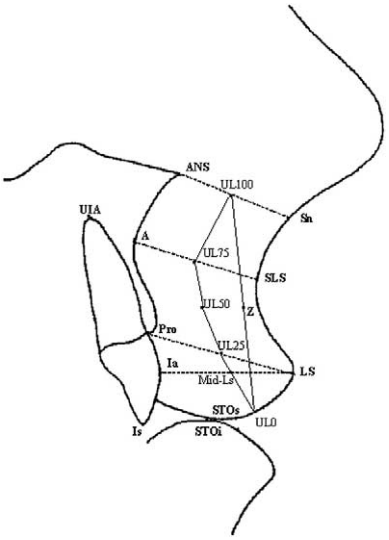

Fig 2. Construction of midlip landmarks.

Table IV. Lip length, thickness, and taper measurements

Measurement		*Explanation*
OLL	Outer lip length	Distance from subnasale to stomion upper lip (Sn-STOs)
MLL	Midlip length	Sum of increments between UL0 and UL100 ([UL100-UL75] + [UL75-UL50] + [UL50-UL25] + [UL25-UL0])
ULT4	Upper lip thickness 4	Distance from anterior nasal spine to subnasale (ANS-Sn)
ULT3	Upper lip thickness 3	Distance from subspinale to superior labial sulcus (A-SLS)
ULT2	Upper lip thickness 2	Distance from prosthion to labrale superius (Pro-LS)
ULT1	Upper lip thickness 1	Distance from incisor anterius to labrale superius (Ia-LS)
Lip taper		Difference between incisor anteriorus to labrale superius and subspinale to superior labial sulcus ([Ia-Ls] – [A-SLS])

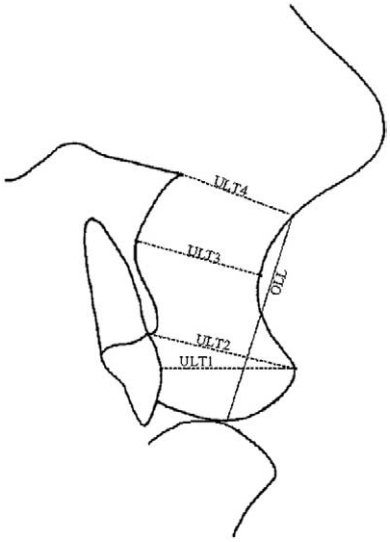

Fig 3. Lip thickness and lip measurements.

(Table VI). The maxillary incisors of blacks were retroclined nearly 3 times as much as whites.

Significant differences were noted in some horizontal dental and soft tissue changes (Table VII). The maxillary incisor apex moved posteriorly 2 mm more in the white group than in the black group. The posterior movement of prosthion (Pro) was also significantly greater (approximately 1 mm) in whites. The white group also showed twice as much posterior movement at subnasale as the black group and over 50% more posterior movement at superior labial sulcus. There was also significantly more posterior movement of the more superior midlip landmarks (UL100, UL75, UL50, and UL25) in whites than blacks.

Group differences in vertical movement pertained to the position of the maxillary incisor crown and lower aspect of the upper lip (Table VII). The black group showed greater inferior movement of incisor superius (1.4 mm) and Pro (0.7 mm) than the white group. Inferior movement of stomion superiorus for the black group was

Table V. Pretreatment cephalometric values for black and white patients

	Black		White		Probability of group differences
	Mean	SD	Mean	SD	
Length					
OLL (mm)	22.2	0.29	20.2	0.37	<.001
MLL (mm)	24.7	0.28	22.34	0.31	<.001
Thickness					
ULT1 (mm)	10.83	0.26	11.31	0.20	.152
ULT2 (mm)	15.07	0.26	13.57	0.19	<.001
ULT3 (mm)	13.74	0.29	12.05	0.21	<.001
ULT4 (mm)	12.5	0.33	11.05	0.25	.001
Relations					
U1SN (°)	113.1	1.54	103.89	1.14	<.001
U1PP (°)	118.77	1.52	111.5	0.98	<.001
Lip taper (mm)	−2.57	2.23	−2.52	1.91	.902

Table VI. Treatment changes in cephalometric values for black and white patients, T1-T2

	Black		White		Probability of group differences
	Mean	SD	Mean	SD	
Length					
OLL (mm)	0.51*	0.19	−0.02	0.27	.111
MLL (mm)	0.07	0.16	−0.20	0.19	.290
Thickness					
ULT1 (mm)	−0.14	0.24	−0.09	0.22	.866
ULT2 (mm)	−0.50	0.28	−0.98*	0.19	.170
ULT3 (mm)	0.35	0.19	0.72*	0.22	.213
ULT4 (mm)	0.59*	0.26	0.50*	0.24	.818
Relations					
U1SN (°)	−12.39*	1.28	−3.80*	1.26	<.001
U1PP (°)	−11.80*	1.37	3.97*	1.24	<.001
Lip taper (mm)	1.09	2.28	1.48	1.82	.379

*$P < .05$.

over 5 times that of the white group. The inferior movement of midlip 0 point was nearly 3 times as much in the blacks.

Table VIII provides regression equations describing the relationships between hard and soft tissue changes for blacks and whites. Multiple regression analysis showed significant differences in slope between the groups, indicating different relationships between hard and soft tissue changes (Table VIII). Changes at superior labial sulcus were approximately twice as great for every millimeter of movement at A-point and anterior nasal spine (ANS) for the white group compared with the black group. Changes in subnasale in the whites were also more than twice as great for every millimeter of movement of either A-point or ANS as compared with the blacks.

Stepwise multiple regression analysis was used to determine the best combination of variables that predict horizontal changes in upper lip position during treatment (Table IX). The horizontal change in Pro was found to be an important determinant in predicting the horizontal change of the upper lip at superior labial sulcus, labrale superiorus, and subnasale (Fig 4). In addition to Pro, subnasale was also influenced by the horizontal change in A-point and ethnicity. Ethnicity indicated that the white group showed 0.36 mm more change in subnasale than did the black group. Superior labial sulcus was also influenced by the horizontal changes in ANS, the initial lip thickness at ULT3, and the change in inclination of the maxillary incisors.

DISCUSSION

Our subjects had pretreatment incisor inclinations, lip lengths, and lip thicknesses similar to those reported in previous studies.[31-33] The black group had greater proclination of the maxillary incisors, whereas the white group had smaller ULT and upper lip length measurements.

Table VII. Horizontal and vertical movements (in millimeters) of hard and soft tissue landmarks (T1-T2)

	Horizontal					*Vertical*				
	Black		*White*		*Probability of group differences*	*Black*		*White*		*Probability of group differences*
	Mean	*SD*	*Mean*	*SD*		*Mean*	*SD*	*Mean*	*SD*	
Hard tissue										
ANS	−0.16	0.28	−0.75*	0.19	0.089	0.49	0.25	0.23	0.17	0.391
A-point	−0.37	0.24	−0.97*	0.21	0.059	0.44	0.33	1.05*	0.27	0.149
Ia	−4.27*	0.33	−3.79	0.36	0.335	−0.76*	0.34	−0.31	0.28	0.308
Is	−5.17*	0.40	−3.99*	0.46	0.055	1.52*	0.28	0.16	0.26	0.001
U1A	−0.33	0.32	−2.23*	0.29	<0.001	−0.14	0.31	0.50*	0.24	0.103
Pro	−2.40*	0.23	−3.28*	0.30	0.023	1.00*	0.26	0.26	0.22	0.035
Soft tissue										
Sn	−0.41*	0.18	−1.11*	0.29	0.042	1.04*	0.26	0.80*	0.24	0.512
SLS	−1.19*	0.25	−1.96*	0.27	0.036	1.53*	0.29	0.71*	0.31	0.052
Ls	−1.94*	0.27	−2.58*	0.33	0.140	1.57*	0.33	1.03*	0.35	0.266
STOs	−2.90*	0.32	−3.04*	0.34	0.774	1.64*	0.32	0.30	0.28	0.002
STOi	−3.59*	0.36	−3.32*	0.37	0.605	0.38	0.33	−0.48	0.37	0.087
Midlip										
UL100	−0.28	0.20	−0.93*	0.21	0.030	0.76*	0.24	0.52*	0.19	0.438
UL75	−0.79*	0.21	−1.46*	0.22	0.029	0.99*	0.26	0.89*	0.25	0.775
UL50	−1.48*	0.20	−2.19*	0.25	0.032	1.14*	0.25	0.76*	0.24	0.279
UL25	−2.17*	0.23	−2.92*	0.30	0.048	1.29*	0.27	0.65*	0.26	0.092
UL0	−2.94*	0.29	−3.28*	0.34	0.438	1.92*	0.31	0.69*	0.28	0.004

*$P < .05$.

Table VIII. Bivariate regression analysis of upper lip soft tissue response to hard tissue treatment changes with correlation (R), constant (C), and slope (S)

		Black			*White*			*Probability of group differences*	
Soft tissue	*Hard tissue*	*R*	*C*	*S*	*R*	*C*	*S*	*C*	*S*
LS	Pro	0.68*	−0.02	0.79	0.78*	0.26	0.86	0.62	0.71
LS	Ia	0.61*	0.12	0.48	0.73*	0.02	0.68	0.87	0.16
LS	Is	0.53*	−0.11	0.36	0.59*	−0.87	0.43	0.28	0.57
LS	U1SN	0.15	−1.56	0.03	0.16	−2.41	0.044	0.18	0.80
SLS	A point	0.47*	−1.01	0.49	0.73*	−1.07	0.93	0.85	0.03
SLS	U1A	0.49*	−1.06	0.38	0.61*	−0.73	0.55	0.39	0.27
SLS	Pro	0.59*	0.37	0.65	0.76*	0.23	0.67	0.79	0.89
SLS	ANS	0.43*	−1.13	0.38	0.61*	−1.34	0.83	0.54	0.03
Sn	ANS	0.45*	−0.36	0.29	0.56*	−0.49	0.83	0.69	0.008
Sn	A point	0.49*	−0.27	0.38	0.72*	−0.16	0.99	0.70	0.001
Sn	U1A	0.46*	−0.32	0.27	0.55*	0.08	0.53	0.29	0.07

*$P < .05$.

Ethnic differences in lip thickness increased from the superior lip thickness measurement to the inferior measurement. Lip taper was not significantly different between the 2 groups. This is probably because ULT1, a determinant of lip taper, was larger in the white group. Lip thicknesses at the other points (ULT2-ULT4) were greater in the black group.

Although pretreatment group differences were noted and significant soft tissue changes were shown, evaluation of the mean treatment changes in upper lip length, taper, and thickness showed no group differences. The subjects showed only slight increases in lip thickness in the inferior half of the upper lip and a small decrease in the superior half. Diels et al,[20] in a study of black females, reported a similar increase in lip thickness at labrale superiorus with retraction of the maxillary incisors. Likewise, Oliver[11] found that white females had little or no change in lip thickness, measured at superior labial sulcus, with maxillary incisor retraction.

The black group had 3 times as much retroclination of

Table IX. Stepwise multivariate regression models for changes (T1-T2) of upper lip by dental and soft and hard tissue variables

Dependent variables	*R**	*SE of estimate*	*Constant*	*Prediction equation*			
				1st	*2nd*	*3rd*	*4th*
Sn	0.72	1.14	0.46	0.31 (ProH)	0.27 (AH)	0.36 (ethnicity)	
SLS	0.78	1.21	0.65	0.60 (ProH)	0.25 (ANSH)	−0.24 (ULT3i)	0.03 (U1SNi)
LS	0.75	1.34	0.11	0.83 (ProH)			

Predictive equations: Y (dependent variable) = constant + (1st) + (2nd) + (3rd) + (4th).
ProH, Prosthion horizontal; AH, A-point horizontal; ANSH, anterior nasal spine horizontal; U1SNi, upper incisor to SN plane pretreatment; ULT3i, upper lip thickness 3 pretreatment.
Ethnicity: black (0) and white (1).
*All values given, $P \leq .001$.

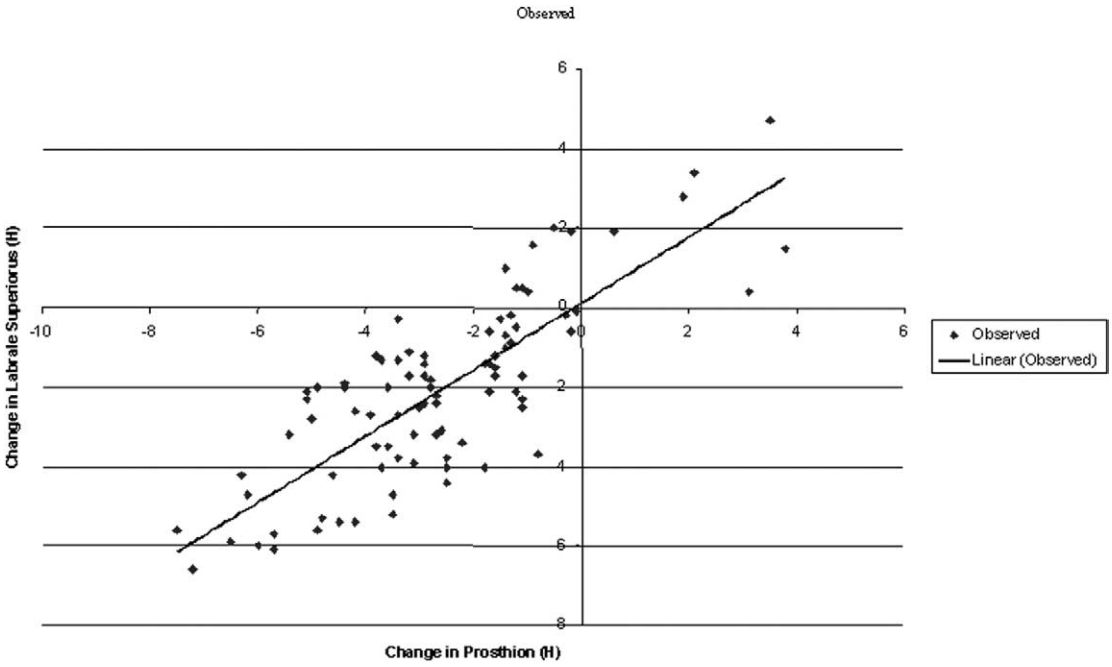

Fig 4. Observed horizontal changes in labrale superius with corresponding changes in prosthion represented as scatter plot and trend line.

the maxillary incisor as the white group during treatment. This difference might be attributable to the greater pretreatment proclination of the maxillary incisors in blacks. However, group differences in maxillary incisor inclination changes did not produce differences in upper lip length and thickness. The greater pretreatment lip thickness in the black group might have masked the treatment changes. Oliver[11] reported that patients with thick lips might respond differently than do patients with thin lips. Patients with thin lips exhibited significantly greater correlations between osseous and hard tissue changes in this study.

The white group showed significantly more posterior movement of the root apex and Pro than the black group. In contrast, the black group showed considerably more posterior movement of the crown than the root apex, nearly twice as much as the white group. This suggests that the black group experienced more tipping movement, whereas the white group underwent more bodily movement. Although the black group experienced more tipping movement, there were no significant group differences in horizontal changes at incisor superius and labrale superiorus.

All vertical hard and soft tissue changes were inferiorly directed, except at incisor anterius and the root apex (white group only). Incisor anterius moved superiorly because of retroclination of the maxillary incisors in both groups; this resulted in repositioning of the most anterior

point on the maxillary incisor. The midlip changes were more inferior in the black group but still increased in dimension from upper to lower midlip points of the upper lip. The black group showed a tendency toward more inferior movement of the hard and soft tissues during treatment, consistent with a greater tipping movement.

Previous studies have used ratios, either Ia:Ls or Is:Ls, to predict soft tissue response to hard tissue movement. This study found Is:Ls ratios of 2.6:1 and 1.5:1 for the black and white groups, respectively. These are consistent with ratios in earlier studies.[7,9,12,14,17-23] The ratios assume, however, that a linear relationship exists, the *y*-intercept passes through 0, the 2 variables that define the ratio explain the changes entirely, and there is an inherent difference between the races in the soft tissue response to incisor retraction. The bivariate regression analyses, which also assume linear relationships, provided estimates for LS that closely approximate the ratios. They also provided estimates for superior labial sulcus and subnasale. Significantly, the bivariate correlations were low to moderate, accounting for 16% to 61% of the variation between hard and soft tissue changes. Lack of correlation helps to explain why group differences in slope—blacks tended to have lower slope values than whites—were not statistically significant. The equations leave other factors unaccounted for, acting to decrease the overall accuracy of the prediction equations.

To overcome this shortfall, stepwise multivariate regression models were derived to predict the changes of the upper lip at sella-nasion line, superior labial sulcus, and labriale superiorus as other variables changed (Table IX). Except for the change at subnasale, considering the ethnicity of the patient does not add significantly to the accuracy of the prediction equation. The multiple regressions did not perform markedly better than the bivariate regression, suggesting that additional factors not included in this study must be considered. The horizontal change at LS, the soft tissue landmark most commonly evaluated in previous studies, is best predicted by using the horizontal change at Pro only. Neither ethnicity nor change at incisor superius increased the correlation significantly.

Evaluation of the prediction equations shows that movement at the interface between the dental and skeletal structures, Pro, contributed most to the soft tissue changes at subnasale, superior labial sulcus, and labrale superiorus. Whereas Talass[14] attributed upper lip change at labrale superiorus to lip thickness and dental variables ($R = 0.69$), our prediction equation was better able to predict changes in labrale superiorus based solely on the changes at Pro ($R = 0.75$).

Bivariate regression analysis found ethnic-group differences in the horizontal change of superior labial sulcus in response to changes in ANS and A-point. The multivariate prediction equation for superior labial sulcus did not include ethnicity as a factor. Instead, initial lip thickness was a factor in the equation. As suggested by Oliver[11] and Kokodynski,[22] thicker lips were found to inversely influence the changes of superior labial sulcus. Greater lip thickness results in less change at superior labial sulcus. Contrary to the findings of Rains and Nanda,[12] maxillary tooth movement was also found to significantly affect superior labial sulcus, as evidenced by the prediction equation inclusion of initial incisor inclination.

Although there are significant differences between whites and blacks in initial lip length, lip thickness, and incisor inclination, the increased maxillary incisor uprighting (retroclination) in the black group during treatment did not result in any significantly different changes between the groups in lip length or thickness. It also appears that greater posterior movement in the incisor crowns of the blacks probably caused the significantly greater inferior vertical movement at stomion superiorus and midlip 0 point. However, these differences might have been due to differences in treatment-induced, vertical-dimension changes. This phenomenon was not evaluated in this study.

CONCLUSIONS

Ethnic differences in the upper lip response to incisor retraction were evaluated in a sample of 88 postpubertal female patients. Hard and soft tissue changes were described and correlations were made between changes in soft tissue variables to changes in hard tissue variables. Although additional research is needed to better understand the relationship between ethnicity and hard and soft tissue changes, the following conclusions can be made:

1. Hard and soft tissue treatment changes of the black group were more downward, and those of the white group were more backward.
2. Ethnic differences exist in the soft tissue response to hard tissue changes in the upper lip at subnasale and superior labial sulcus, but these response differences at SLS can be explained by the ethnic differences in initial lip thickness and incisor inclination. They are not due to ethnicity.
3. The change at Pro was significantly correlated with the response of the upper lip at labrale superiorus to incisor retraction. Ethnicity did not improve the predictability of the response.
4. When incisor retraction was performed, the final, horizontal, upper lip position could be accurately and reliably predicted.

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