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UPPER LIP CHANGES CORRELATED WITH MAXILLARY INCISOR MOVEMENT IN 65 ORTHODONTICALLY TREATED ADULT PATIENTS

Aim: *To describe the behavior of the upper lip components following orthodontically induced movement of the maxillary incisor in a sample of 65 adults.* ***Methods:*** *The study sample was divided into 2 groups: the retraction group, made up of 35 patients in whom the incisor had been moved in a palatal direction (tipping), and the protraction group, consisting of 30 patients who had undergone labial movement of the incisor (tipping). To evaluate the mean changes in lip position and quality of the patients' profiles between T1 (before movement of the incisor) and T2 (after movement of the incisor), we measured the following parameters: variation in upper lip thickness (DUVT), variation in the depth of the labial sulcus (DULSD), variation in vermillion height (DUVH), variation in upper lip length (DULL), variation in maxillary incisor exposure (Dls-STOs), and DSTOs and STOi, which indicate a variation in the gap between the lips.* ***Results:*** *In the retraction group, all soft tissue parameters showed significant changes at T2, except for DUVT and DULL, while in the protraction group, the significance of the mean changes was decidedly lower and resulted higher for only DULSD and DUVT. Nevertheless, multiple linear regression analysis highlighted the unfeasibility of predicting the behavior of the dependent (cutaneous) variables except for DUVH and DULSD in the protraction group.* ***Conclusion:*** *The results obtained highlight a pronounced variability among the patients studied and the impossibility of accurately predicting the behavior of the soft tissues following movement of maxillary incisors.* World J Orthod 2008;9:337–348.

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Facial harmony and balance are determined by the interaction among various factors, including skeletal characteristics, quality of the soft tissues, and the position and degree of inclination of the teeth.[1–3]

The treatment plan must include analysis of all these factors to correct dentoskeletal disharmonies and obtain an optimal esthetic result vis a vis position of the lips and perioral soft tissues. Indeed, basing the treatment plan on solely skeletal analysis does not necessarily produce the desired result, as correct occlusion does not necessarily correspond to good facial equilibrium.[4]

Despite the fact that movement of the maxillary incisors leads to modification of the perioral soft tissues has been widely intuited and amply demonstrated, how these factors are correlated is still a subject of research. The majority of studies have evaluated the difference in soft tissue response following retraction of the incisors in extraction cases,[5–7] no other study has reported the behavior of the lip following labial movement.

Some studies have found a large degree of correlation between retraction of the maxillary incisors and retraction of the lip,[8–11] while others have reported that a change in occlusion is not neces-

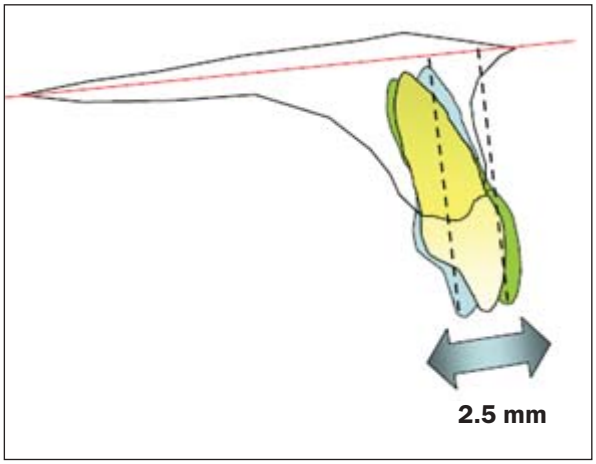

Fig 1 Superimposition of the tracings on the palatal plane, obtained before (T1) and after (T2) orthodontic treatment, to measure the distance between the orthogonal projections of the incisal points.

sarily accompanied by a modification in the patient's profile.[12–15]

Ricketts[6] observed a sample of 1,000 patients treated for a "common orthodontic problem" and reported that the upper lip increased in thickness by an average of 1 mm for every 3 mm of retraction of the maxillary incisor. In a sample of 27 males and 43 females, Anderson et al[16] found that the relationship between lip thinning and maxillary incisor retraction to be 1:1.5 mm. Oliver,[17] in a study of 40 patients (20 males and 20 females) between 12 and 15 years of age, evidenced a strong correlation between retraction of the incisors and labial retraction following orthodontic treatment in patients with thin lips. The abovementioned difference in behavior of the lips due to racial differences was analyzed by Brock et al[18] in a sample of 44 African-American adult females and 44 Caucasian adult females (average age 18.45 for both groups). They showed how the labial response to retraction of the incisor was directed mainly downward in African-American patients in contrast to the retraction of the soft tissue complex observed in Caucasian patients.

To date, only a few authors[19,20] have considered the depth of curvature of the lip, and little information is therefore available regarding changes in lip curvature associated with large movements of the maxillary incisor as occurs in, for example, extraction treatment.[21–24] Moseling and Woods[24] analyzed the behavior of soft tissues following both extraction and nonextraction orthodontic treatment in a sample of 137 females: They concluded that there were no significant statistical differences between the extraction and nonextraction groups as far as curvature of the lip was concerned and that extraction treatment does not necessarily modify the depth of curvature of the lip.

Jacobs[25] was among the first authors to analyze alterations in vermillion height and, in a study of 20 patients between the ages of 11 and 16 who underwent extraction treatment with retraction of the maxillary incisor, found a reduction in the height of the vermillion that decreased, on average, by 1.6 mm for the upper lip and 1.3 mm for the lower. Perkins and Staley[26] analyzed 40 Caucasian adult females and concluded that there was no direct or significant relationship between retraction of the maxillary incisor and reduction in upper vermillion height.

The aim of this study was to describe the behavior of the upper lip following movement of the maxillary incisor and analyzing, where present, the influence and type of dental movement on the modification of the lip to assess a correlation between the dental and cutaneous components that, if confirmed, could be most helpful in developing treatment plans for improving the profile.

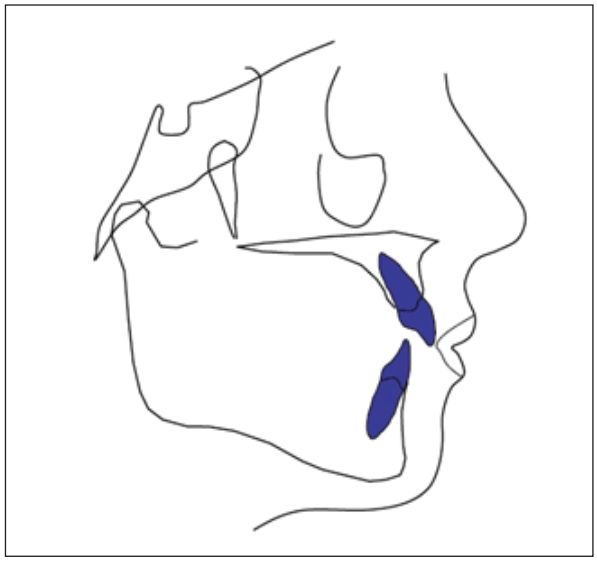

Fig 2 Cephalometric tracings.

METHODS

The records of 343 consecutively treated orthodontic patients over the age of 20 were analyzed. Patients who had undergone movement of tipping the maxillary incisor in the labial or palatal direction of at least 2.5 mm were selected. This movement was evaluated by superimposing the tracings obtained by lateral head films before (T1) and after (T2) treatment. The superimposition was carried out on the palatal plane, and the distance between the orthogonal projections of the incisal points at T1 and T2 on the palatal plane was measured (Fig 1). An expert investigator carried out all tracings by hand. The age limit was chosen to minimize the influence of growth on the modification of the soft tissues, as skeletal and perioral tissue growth is markedly reduced after the age of 20.[25–28]

Thus, for this study, 65 patients (26 males and 39 females) were considered. The average age of the sample was 30.6 ± 9.

The sample group was divided into subgroups on the basis of the direction of the movement of the incisor: the retraction group, 35 patients (average age, 29.5) in whom the dental tipping occurred in a palatal direction, and the protraction group, 30 patients (average age, 31.9) in whom the dental tipping occurred in a labial direction.

The sample was chosen from the patients of 5 specialist orthodontists, 4 of whom belong to the American Board of Orthodontics and the fifth an active member of the Angle Society of Europe and the Italian Board of Orthodontics.

Lateral headfilms of the selected patients' skulls, taken before (T1) and after (T2) treatment, were analyzed.

To favor sample homogeneity, all radiographs had clear definition of the soft tissues (including the vermillion), molars in occlusion, and natural patient positioning with relaxed lips.

The tracings (Fig 2) included skeletal structures for superimposition, ie, the base of the skull, pteryomaxillary fissure, zygomaxillary point, orbits and skull, as well as incisor outlines, cutaneous profile from glabella to cutaneous menton, and a clear outline of the vermillion.

Identification of the anatomical points (Fig 3) was based on conventional definitions described in literature.[1–3,13,26,29]

The identified anatomical points were:

- Sn' (Subnasale): the highest point of the upper lip, 3 mm below the skeletal Sn
- At (soft tissue A-point): the most concave point between the subnasale and the labrale superior
- Ls (Labrale superior): the point of the upper lip where the vermillion begins;
- STOs (Stomion superior): the lowest point of the upper lip (in cases of labial incompetence)
- STOi (Stomion inferior): the highest point of the upper lip (in cases of labial incompetence)

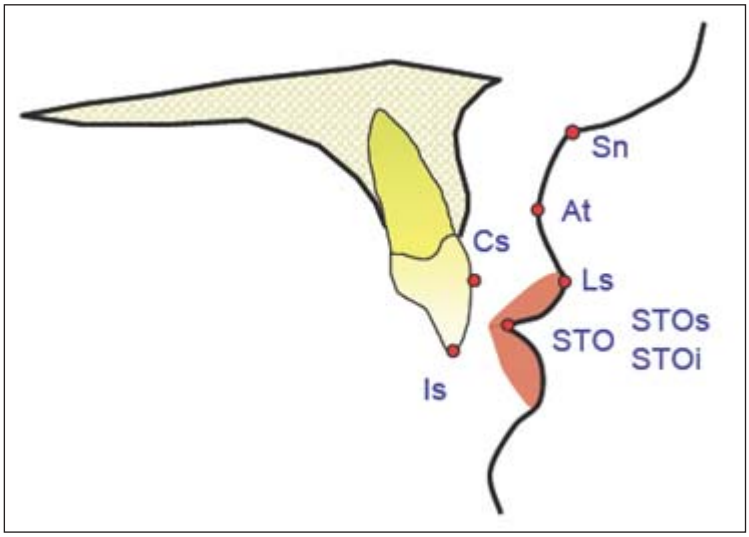

Fig 3 Schematic representation of the cephalometric points considered.

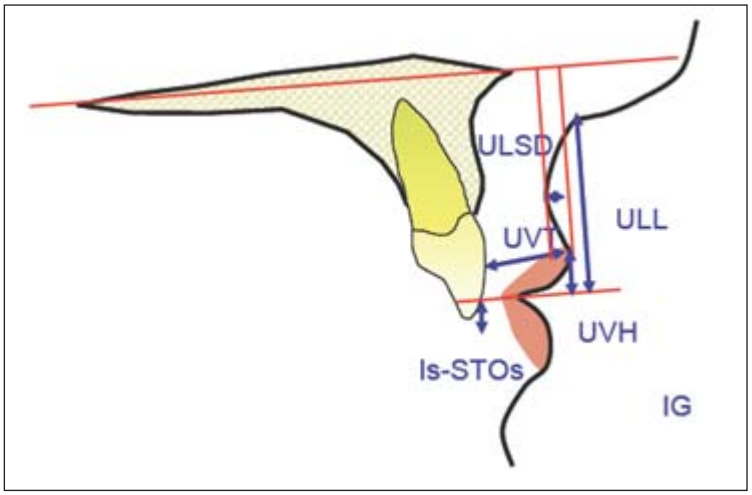

Fig 4 Schematic representation of the cephalometric measurements carried out.

- STO (Stomion): the anteriormost point of labial contact
- Is (incision superior): the incisal point of the maxillary incisor crown
- Cs (crown superior): the anterior-most point of the maxillary incisor crown

To evaluate the posture of the lip and the quality of the profile, we measured the following parameters (Fig 4):

- Upper vermillion thickness (UVT): the shortest distance between Ls and the labial surface of the maxillary incisor
- Upper labial sulcus depth (ULSD): measured between the lines perpendicular to the palatal tangents at Ls and At
- Upper vermillion height (UVH): the distance between Ls and STOs
- Upper lip length (ULL): the distance between Sn' and STOs
- The vertical distance between the incision superior and Stomion superior (Is-STOs), ie, the exposure of the incisor (when Is was found below STOs, the value was considered positive and vice versa negative)
- IG (Interlabial gap): the distance between STOs and STOi (in cases of labial incompetence)

After tracings were obtained at T1 and T2, best-fit superimpositions were carried out using the pteryomaxillary fissure, zygomaxillary point, orbits, and stable

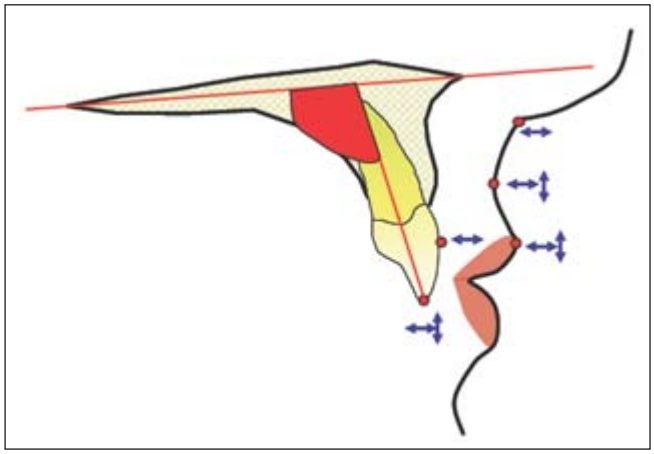

Fig 5 Horizontal and vertical measurements of the distances between analogous points of the 2 tracings.

skull anatomical structures according to Björk.[30] Subsequently, the horizontal and vertical measurements between the analogous points on the 2 tracings were obtained.[31–33] Two arrows denoted movements in an anterior or upward direction, and 1 arrow indicated movement in a posterior or downward direction (Fig 5).

Measurements carried out were the following:

- The horizontal distance between Sn' points (DxSn')
- The horizontal distance between At points (DxAt)
- The horizontal distance between Ls points (DxLs)
- The vertical distance between Ls points (DyLs)
- The horizontal distance between Is points (DxIs)
- The vertical distance between Is points (DyIs)
- The horizontal distance between Cs points (DxC)
- The axial inclination of the maxillary incisor (1/PP) with respect to the palatal plane (ANS-PNS) at T1 and T2

Furthermore, the following values were obtained by subtracting the measurements taken at T2 from their equivalents at T1:

- Mean change in upper lip thickness (DUVT)
- Mean change in labial sulcus depth (DULSD)
- Mean change in vermillion height (DUVH)
- Mean change in upper lip length (DULL)
- Mean change in maxillary incisor exposure (DIs-STOs)
- Mean change in the interlabial gap (DSTOs and STOi)

All mean changes measured are represented in Fig 6. The mean changes in Dx (horizontal movement) and Dy (vertical movement) values are denoted with horizontal and vertical lines, respectively, if the movement between T1 and T2 was upward or to the right or a minus sign where the movement between T1 and T2 occurred downward or to the left. The difference between the angular values (DPP/1) was obtained by subtracting the PP/1 measured at T2 from that at T1 (T2-T1). Negative values indicated movement of the incisor in a palatal direction, ie, away from the upper lip, whereas positive values represented a labial movement toward the lip.

To evaluate the reliability of the cephalometric measurements, all measurements of variables were repeated in 20 patients randomly selected from the sample group.

Method error was calculated using Dahlberg's formula[34] $S_x = \sqrt{(SD_i^2/2M)}$, in which M indicates the number of duplicated measurements and D_i the difference between the i^{th} pairs of measurements repeated.[35]

No significant difference was found in any of these cases.

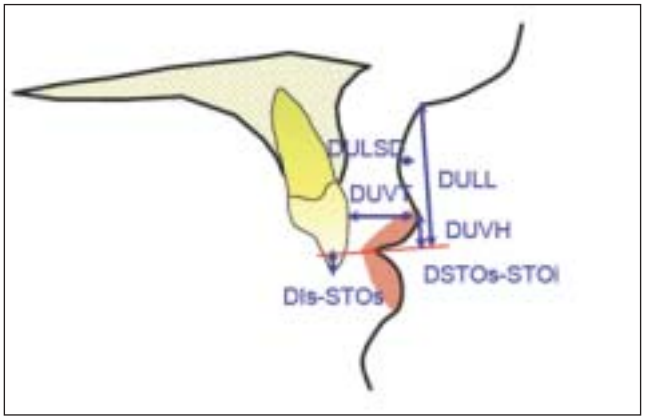

Fig 6 Representation of the mean changes of cephalometric measurements.

Table 1 Mean variation, standard deviation, and significance values calculated using Student's *t* test in the parameters considered in the retraction group

	Mean	SD	*P*
DxIs (mm)	3.75	0.67	.001
DyIs (mm)	0.17	1.2	.55
DxCs (mm)	1.89	0.85	.001
DyLs (mm)	0	1.04	1
DxLs (mm)	0.19	1.26	.52
DxAt (mm)	−0.25	0.83	.21
DxSn (mm)	−0.11	0.72	.52
DULSD (mm)	0.50	0.59	.001
DUVH (Ls-STOs) (mm)	0.36	0.93	.12
DUVT (mm)	−1.53	1.5	.001
Dis-STOs	−0.07	1.06	.05
DULL (Sn'-STOs) (mm)	0.25	0.85	.22
D1/PP (degrees)	14.5	5.7	.001

To compare several values at once, multiple linear regression analysis was carried out. This indicated the degree of association between a single, dependent variable and the independent variables.

Independent variables were defined as all parameters relative to dental movement together with the lip thickness: DxIs, UVT (T1), Is-STOs (T1), Is-STOs (T2), and Dx 1/PP.

The parameters that changed following dental movement were those relative to the soft tissues, components of the upper lip, and were therefore defined as dependent variables: DxLs, DUVH (Ls-STOs), and DULSD.

Each of these dependent values was considered as Y in the following equation to determine the line in the multiple linear regression:

$$Y=m1x1+m2x2+m3x3+m4x4+m5x5+b,$$

where x1, x2, x3, x4 ,and x5 represent the 5 abovementioned independent values and m the coefficients corresponding to each *x* value. On the other hand, b is a constant that indicates the value of Y at each point at which the line intersects the Y-axis.

Subsequently, the correlation coefficient, or r^2 index, was calculated. This compared the Y values expected with those obtained. Once the linear r^2 correlation index from the regression line was calculated, the F test (analysis of variance, ANOVA) was employed to verify whether the relationship between the dependent and independent variables was random or determined by a systematic factor.

Table 2 Mean variation, standard deviation, and significance values calculated using Student's t test in the parameters considered in the protraction group

	Retraction group		Protraction group	
	Mean	SD	Mean	SD
Maxillary incisor incisal point, DxCs	−3.35	2	1.89	0.85
Distance between Ls points, DxLs	−1.82	1.93	0.19	1.26
Labial sulcus depth, DULSD (mm)	−0.65	1.13	0.50	0.59
Vermillion height, DUVH (mm)	−0.86	1	0.36	0.93
Upper lip thickness, DUVT (mm)	0.84	2.09	−1.53	1.5
Upper lip height, DULL (mm)	−0.46	1.57	0.25	0.85

Table 3 Main changes for retraction compared to protraction group

	Mean	SD	Significance (*P*)
Dxls (mm)	−4.39	2.49	.001
Dyls (mm)	−0.75	1.5	.005
DxCs (mm)	−3.35	2	.001
DyLs (mm)	−1.10	1.67	.001
DxLs (mm)	−1.82	1.93	.001
DxAt (mm)	−1.36	1.36	.001
DxSn (mm)	−0.36	1.24	.001
DULSD (mm)	−0.65	1.13	.001
DUVH (Ls-STOs) (mm)	−0.86	1	.001
DUVT (mm)	0.84	2.09	.05
Dls-STOs	0.13	0.68	.35
DULL (Sn'-STOs) (mm)	−0.46	0.57	.075
D1/PP (degrees)	−7.50	8.9	.001

RESULTS

Tables 1 and 2 show the mean changes in the parameters considered, the standard deviations, and the significance values calculated using Student's *t* test, while Table 3 summarizes the main changes for retraction compared to protraction group. In the retraction group, the retraction of the incisor had a significant effect on all the components analyzed; point ls underwent a mean palatalization of 4.39 ± 2.49 mm and a mean intrusion of 0.75 ± 1.5 mm and Cs a mean retraction of 3.35 ± 2 mm. The angle between the axis of the incisor and the palatal plane was reduced on average by 7.50 ± 8.9 degrees.

The soft tissue points also underwent highly significant modifications, except for the length and thickness of the lip. Point Ls moved backward and downward by 1.82 ± 1.93 mm and 1.10 ± 1.67 mm, respectively. The downward movement of point Ls caused a significant reduction in vermillion height DUVH (Ls-STOs) (−0.86 ± 1 mm) and a less pronounced and much less significant lengthening of the lip DULL (Sn'-STOs) (−0.46 ± 0.57 mm). Point Sn also underwent a significant retraction (−0.36± 1.24 mm), and even though point At moved backward on average by 1.36 ± 1.36 mm, the increased mean value of DxLs led to a mean reduction in labial sulcus depth of 0.65 ± 1.13 mm. The lip thickness increased by 0.84 ± 2.09 mm, although this was not considered highly significant (*P* <.01).

In the protraction group, on the other hand, the mean variation was substantially lower. The only increased values were Dxls (3.75 ± 0.67 mm), DxCs (1.89 ± 0.85 mm), DUL sulcus depth (0.50 ± 0.59), D1/PP (14.5 ± 5.7 degrees), and the thickness of the lip, DUV, which, unlike in the protraction group, underwent a significant change (−1.53 ± 1.5 mm). The angle between the axis of the incisor and the palatal plane increased by 14.5 ± 5.7 degrees on average. The other values in this group, while tendentially consistent with those previously mentioned, underwent less significant change. Point Ls, for example, showed a

Table 4 Percentage variation in cutaneous variables (and respective SDs) due to independent variable DxIs (if variation in dental variable is considered as 100%)

	Retraction ± SD (%)	Protraction ± SD (%)
DxLs	42.64 ± 48.36	6.5 ± 34.85
DyLs	30.24 ± 51.99	1.37 ± 28.65
DxAt	30.99 ± 37.78	−6.16 ± 22.97
DUL Sulcus depth	14.93 ± 34.63	14.64 ± 16.81
DuVH (Ls-STOs)	25.60 ± 27.20	12.05 ± 27.47

Table 5 Percentage variation in cutaneous variables (and respective SDs) due to independent variable DyIs (if variation in dental variable is considered as 100%)

	Retraction ± SD (%)	Protraction ± SD (%)
DxLs	41.79 ± 256.12	2.38 ± 119.19
DyLs	29.27 ± 154.37	22.62 ± 112.78
DxAt	63.33 ± 212.45	−1.19 ± 85.85
DUL Sulcus depth	11.97 ± 93.71	−9.52 ± 82.62
DuVH (Ls-STOs)	16.53 ± 112.95	7.14 ± 96.98

Table 6 Percentage variation in cutaneous variables (and respective SDs) due to independent variable DxCs (if variation in dental variable is considered as 100%)

	Retraction ± SD (%)	Protraction ± SD (%)
DxLs	56.69 ± 66.96	8.04 ± 71.46
DyLs	43.14 ± 73.98	−0.49 ± 60.57
DxAt	39.70 ± 48.52	−31.18 ± 79.60
DUL Sulcus depth	23.55 ± 44.17	36.67 ± 54.74
DuVH (Ls-STOs)	30.24 ± 38.13	25.69 ± 50.93

Table 7 Percentage variation in cutaneous variables (and respective SDs) due to independent variable DyCs (if variation in dental variable is considered as 100%)

	Retraction ± SD (%)	Protraction ± SD (%)
DxLs	17.13 ± 87.66	1.74 ± 11.88
DyLs	21.78 ± 53.05	−0.01 ± 9.94
DxAt	15.86 ± 79.43	−1.32 ± 7.88
DUL Sulcus depth	6.64 ± 31.14	3.67 ± 5.32
DuVH (Ls-STOs)	12.98 ± 42.52	2.74 ± 10.26

Table 8 Percentage variation in cutaneous variables (and respective SDs) due to independent variable DUVT (if variation in dental variable is considered as 100%)

	Retraction ± SD (%)	Protraction ± SD (%)
DxLs	41.82 ± 291.33	2.38 ± 118.19
DyLs	49.09 ± 271.94	22.62 ± 112.78
DxAt	0.18 ± 204.77	−1.19 ± 85.85
DUL Sulcus depth	26.54 ± 125.97	−9.52 ± 82.62
DuVH (Ls-STOs)	32.73 ± 138.39	7.14 ± 96.98

mean vertical change of 0 ± 1.04 mm, and values for DAt and Dsn, contrary to expectations, displayed a small reduction, while the depth of the sulcus was modestly increased.

The exposure of the incisor (Is-Stos) at T1 was, on average, 3 ± 3.6 mm in the retraction group and 3.4 ±1.6 mm in the protraction group. This was increased by a mean of 0.13 ± 1.68 mm in the retraction group and reduced by a mean of −0.07 ± 1.06 mm in the protraction group at T2. Both of these alterations proved to be of little significance.

For every 1 mm of incisor retraction, there was, on average, about 0.54 mm of lip retraction, about 0.19 mm of labial sulcus depth reduction, about 0.26 mm of vermillion height reduction, about 0.25 mm in upper lip thickness increase, and about 0.14 mm of upper lip height reduction. For every 1 mm of incisor protraction, there was 0.10 mm of lip protrusion, about 0.26 mm of labial sulcus depth increase, about 0.19 mm of vermillion height increase, about 0.8 mm in upper lip thickness reduction, and about 0.13 mm of upper lip height increase.

Once the parameters that had undergone the most significant modifications had been identified, in accordance with previous studies,[6,16,36] we decided to quantify the extent to which the soft tissues were affected by those dental variables. DxLs, DyLs, DxAt, DUVH (Ls-STOs), and DULSD of both groups are expressed as a percentage of the independent variables (considering the mean changes in dental variables as 100%) in Tables 4 to 8, and the standard deviations and percentage of change of each soft tissue variable was calculated. Positive percent-

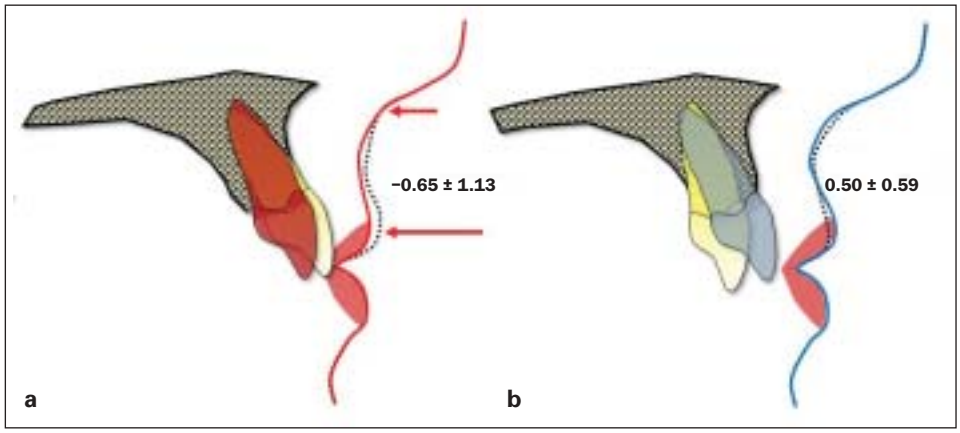

Fig 7 Representation of the mean changes in labial sulcus depth (DULSD) in the retraction group **(a)** and protraction group **(b)**.

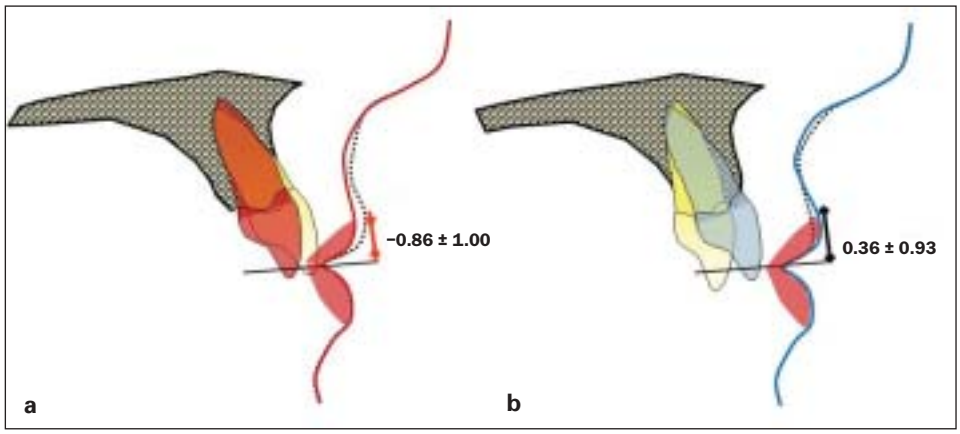

Fig 8 Representation of the mean changes in vermillion height (DUVH) in the **(a)** retraction group and **(b)** protraction group.

ages indicate that the parameter considered moved in the direction of the principal variable (labial/upward or palatal/downward) and negative values indicate the opposite.

The multiple linear regression analysis, correlation coefficient, and r^2 index indicate the unfeasibility of predicting the behavior of the dependent (cutaneous) variables based upon the behavior of the independent (dental) variables. In almost all cases, the correlation coefficient was 0.1, which indicates a poor relationship between variables. The sole 2 variables that differ from this tendency were vermillion height (DUVH) and sulcus depth (DULSD), which, in the protraction group, were only $r^2 = 0.4$ and $r^2 = 0.3$, respectively (Figs 7 and 8).

DISCUSSION

Upon analysis of the results, the extreme variability between individuals is evident. This confirms results already evidenced in other studies[10,22,24,37,38] and has been attributed to elusive factors intrinsic to the structure of the lip.

The mean changes in most parameters considered were statistically significant, but despite the fact that the mean dental changes in both groups were very similar (DxIs, DyIs, DxCs), or even more than double (D1/PP) in the protraction group, the modifications noted in the retraction group were more significant than in the protraction group.

Lip thickness, as previously documented,[6,16,17] was only moderately increased in the retraction group. Wisth[39] found that the lip response to

increasing lip retraction was increasingly weaker, ie, the lip is decreasingly influenced by retraction of the incisor after a certain point.

This is the first study to quantify lip changes from labial movement of the incisor. In the protraction group, a statistically significant reduction in lip thickness was observed. Considering that the mean lip thickness at T1 was 11.5 ± 2.7 mm in the retraction group and 11.8 ± 2.7 mm in the protraction group, ie, very similar, the differing behavior suggests that the incisor movement was in some way absorbed by the lip thickness, which therefore masked the effect on the profile in the labial movement group.

In the retraction group, the sulcus depth was reduced due to a greater retraction of point Ls with respect to At, whereas in the protraction group, the forward movement of point Ls and the retraction of point At led to an increase in the same parameter.

In the abovementioned Moseling and Woods study,[24] the differences between extraction and nonextraction sample groups were found to be insignificant, although the direction of the incisor movement was not specified. Our research, however, evidenced a statistically significant flattening of the curve in the retraction group and the opposite effect in the protraction group.

In the retraction group, a statistically significant difference in vermillion height of approximately 1 mm was found, while in the protraction group, the vermillion height remained unchanged. Ramos et al found a decrease of 0.9 to 1.2 mm in the vertical extension of the upper lip vermilion after the extraction of maxillary first premolars and subsequent anterior tooth retraction in 16 Class II Division 1 patients using superimpositions on Björk-type metallic implants in the maxilla.[40] Perkins and Staley measured changes in the vermillion during treatment of Class I and Class II adults, demonstrating that retraction of the incisors causes a reduction in vermillion height.[26] Furthermore, according to these authors, if the exposure of the incisor is less than 6 mm, movement of the incisor exerts a greater influence on the modification of the vermillion. We contest, however, the validity of 6 mm as a threshold value as it is arbitrary and rarely seen in clinical cases (in our sample, the mean exposure of the incisor was far less); also, preferred multiple linear regression analysis as a more accurate means of ascertaining any relationship among changes in the vermillion due to incisor movement. However, we concur with Scott et al[41] that the effect of incisor movement on vermillion height is fundamental, as it may have negative effects on the esthetic result.

Kocadereli[22] found that the change in protuberance of the lip is highly individual, and a marked retraction of the incisor can cause a pronounced reduction in lip protrusion in some patients, while in others, the same degree of retraction produces only a slight reduction, and attributed this to the structure of the lip, which appears to influence its own response to incisor retraction. This variability in response between individuals is also very evident in our sample, as shown by our graphical analysis, which highlights the fact that the standard deviation has a larger magnitude than the mean percentage relationship in a theoretical ratio of the behavior of 1 variable with respect to another.

The most significant proof of the individual nature of lip reaction, however, is evidenced by the multiple regression analysis which, as well as indicating the lines for each dependent (cutaneous) variable, shows, with the correlation coefficient, that soft tissue behavior is impossible to predict using only the behavior of the independent (dental) variables.

The independent variables therefore play a minor role in predicting modifications in the dependent variables, ie, the behavior of the variables relative to the upper lip is only partially explained by the multiple regression. The only 2 variables that strayed from this pattern were the vermillion height (DUVH) and the sulcus depth (DULSD) in the protraction group.

CONCLUSION

The results obtained in this study highlighted, as well as a large variability in behavior among patients, the impossibility of accurately predicting the behavior of the soft tissue components of the lip following movement of the maxillary incisors, whether in a labial or palatal direction. In other words, the modifications in the perioral tissues relative to the upper lip in our sample were only partially explainable by the dental movement and could be correlated to other factors not considered in this study. The mean changes in the parameters considered and their relative percentages may only be considered as guide by the dental professional as the final result may differ significant from that predicted due to as yet unexplained factors.

REFERENCES

1. Arnett GW, McLaughlin RP. Facial and dental planning for orthodontists and oral surgeons. St Louis: Mosby, 2004.
2. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part II. Am J Orthod Dentofacial Orthop 1993;103: 395–411.
3. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. Am J Orthod Dentofacial Orthop 1993;103: 299–312.
4. Bergman RT. Cephalometric soft tissue facial analysis. Am J Orthod Dentofacial Orthop 1999;116:373–389.
5. Talass MF, Talass L, Baker RC. Soft-tissue profile changes resulting from retraction of maxillary incisors. Am J Orthod Dentofacial Orthop 1987;91:385–394.
6. Ricketts RM. Cephalometric synthesis. Am J Orthod 1960;46:647–673.
7. Drobocky OB, Smith RJ. Changes in facial profile during orthodontic treatment with extraction of four first premolars. Am J Orthod Dentofacial Orthop 1989;95:220–230.
8. Bloom LA. Perioral profile changes in orthodontic treatment. Am J Orthod 1969;47:371–379.
9. Rudee DA. Proportional profile changes concurrent with orthodontic therapy. Am J Orthod 1964;50:421-434.
10. Garner LD. Soft-tissue changes concurrent with orthodontic tooth movement. Am J Orthod 1974;66:367–377.
11. Riedel R. Esthetics and its reletion to orthodontic therapy. Angle Orthod 1950 20:168–178.
12. Angelle PA. A cephalometric study of soft tissue changes during and after orthodontic treatment. Trans Eur Orthod Soc 1973;49:267–280.
13. Hershey HG. Incisor tooth retraction and subsequent profile change in postadolescent female patients. Am J Orthod 1972;61:45–54
14. Burstone CT. The integumental profile. Am J Orthod 1958;44:1–25.
15. Tadic N, Woods M. Incisal and soft tissue effects of maxillary premolar extraction in Class II treatment. Angle Orthod 2007;77: 808–816.
16. Anderson JP, Joondeph DR, Turpin DL. A cephalometric study of profile changes in orthodontically treated cases ten years out of retention. Angle Orthod 1973;43:324–336.
17. Oliver BM. The influence of lip thickness and strain on upper lip response to incisor retraction. Am J Orthod 1982;82:141–149.
18. Brock RA 2nd, Taylor RW, Buschang PH, Behrents RG. Ethnic differences in upper lip response to incisor retraction. Am J Orthod Dentofacial Orthop 2005;127:683–691.
19. Boley JC, Pontier JP, Smith S, Fulbright M. Facial changes in extraction and nonextraction patients. Angle Orthod 1998;68:539–546.
20. Wilson JR, Little RM, Joondeph DR, Doppel DM. Comparison of soft tissue profile changes in serial extraction and late premolar extraction. Angle Orthod 1999;69:165–174.
21. Bravo LA, Canut JA, Pascual A, Bravo B. Comparison of the changes in facial profile after orthodontic treatment, with and without extractions. Br J Orthod 1997;24:25–34.
22. Kocadereli I. Changes in soft tissue profile after orthodontic treatment with and without extractions. Am J Orthod Dentofacial Orthop 2002; 122:67–72.
23. James RD. A comparative study of facial profiles in extraction and nonextraction treatment. Am J Orthod Dentofacial Orthop 1998;114: 265–276.
24. Moseling KP, Woods MG. Lip curve changes in females with premolar extraction or nonextraction treatment. Angle Orthod 2004;74:51–62.
25. Jacobs JD. Vertical lip changes from maxillary incisor retraction. Am J Orthod 1978;74: 396–404.
26. Perkins RA, Staley RN. Change in lip vermillion height during orthodontic treatment. Am J Orthod Dentofacial Orthop 1993;103:147–154.
27. Nanda RS. The rates of growth of several facial components measured from serial cephalometric roentgenograms. Am J Orthod 1955;41: 658–673.
28. Downs WB. Variations in facial relationships: Their significance in treatment and prognosis. Am J Orthod 1948;34:812–840.
29. Riolo ML, Moyers RE, McNamara JA, Hunter WS. An Atlas of Craniofacial Growth, monograph 2. Ann Arbor: University of Michigan, 1974.
30. Bjork A. Sutural growth of the upper face studied by implant method. Acta Odontol Scand 1966;24:109–127.
31. Björk A, Skieller V. Growth of the maxilla in three dimensions as revealed radiographically by the implant method. Br J Orthod 1977;4: 53–64.

32. Björk A, Skieller V. Roentgencephalometric growth analysis of the maxilla. Trans Eur Orthod Soc 1977;7:209–233.
33. Björk A, Skieller V. Facial development and tooth eruption. An implant study at the age of puberty. Am J Orthod 1972;62:339–383.
34. Dahlberg G. Statistical Methods for Medical and Biological Students. New York: Interscience Publications, 1940.
35. Finnöy JP, Wisth PJ, Böe OE. Changes in soft tissue profile during and after orthodontic treatment. Eur J Orthod 1987;9:68–78.
36. Scott Conley R, Jernigan C. Soft tissue changes after upper premolar extraction in Class II camouflage therapy. Angle Orthod 2006;76:59–65.
37. Lai J, Ghosh J, Nanda RS. Effects of orthodontic therapy on the facial profile in long and short vertical facial patterns Am J Orthod Dentofacial Orthop 2000;118:505–513.
38. Zierhut EC, Joondeph DR, Artun J, Little RM. Long-term profile changes associated with successfully treated extraction and nonextraction Class II Division 1 malocclusions. Angle Orthod 2000;70:208–219.
39. Wisth J. Soft tissue response to upper incisor retraction in boys. Br J Orthod 1974;1: 199–204.
40. Ramos A, Sakima M, Pinto A, Bowman SJ. Upper lip changes correlated to maxillary incisor retraction—A metallic implant study. Angle Orthod 2005;75:499–505.
41. Scott CR, Goonewardene MS, Murray K. Influence of lips on the perception of malocclusion. Am J Orthod Dentofacial Orthop 2006;130: 152–162.