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TURKISH JOURNAL OF ORTHODONTICS

Original Article

Does Lip Change Following Premolar Extraction Differ in Patients with High and Normal Vertical Growth Patterns?

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Main Points

- Lip changes following premolar extraction differ between patients with high and normal vertical growth patterns.
- Upper lip retraction is more pronounced in patients with a high vertical growth pattern.
- Vertical growth pattern and lip strain should be considered when predicting soft tissue response to extraction therapy.

ABSTRACT

Objective: To evaluate the relationship between incisor retraction and upper and lower lip repositioning in patients with high and normal vertical growth patterns (NVP), and to assess whether vertical growth pattern influences soft tissue changes following extraction treatments.

Methods: Pre- and post-treatment lateral cephalograms of 79 patients who underwent extraction of two or four first premolars were analyzed. Patients were divided into a [high vertical pattern (HVP); Frankfort-mandibular plane angle (FMA) >30°, n=49] and a NVP; 22< FMA ≤30°, n=30) group. Horizontal and vertical changes in the lips, labiomental fold, and lip strain were measured, and correlations between these changes and incisor movements were assessed.

Results: Upper lip retraction was greater in the HVP group (2.86 mm, $p<0.05$) than in the NVP group (1.97 mm, not significant). Upper lip height decreased significantly in both groups, with a slightly greater decrease in the NVP group ($p<0.001$). Upper lip strain decreased in both groups, especially in the HVP group ($p<0.001$). Incisor retraction was strongly correlated with upper-lip changes in both groups, and with lower-lip and labiomental-fold repositioning in the NVP group.

Conclusion: Soft tissue response to incisor retraction varies with vertical growth pattern, with greater upper lip retraction in HVP patients. Vertical growth patterns should be considered for optimal soft tissue outcomes.

Keywords: Orthodontic extraction, soft tissue profile, mandibular growth pattern, lip strain, labiomental fold

INTRODUCTION

People's appreciation of facial attractiveness has increased alongside the growing popularity of uploading photos to social media. Consequently, planning and outcomes of orthodontic treatments that may affect an individual's profile have become increasingly important owing to greater awareness of facial alterations. One of the orthodontic treatment modalities that has the greatest impact on profile is premolar extraction.[1] Premolars are most frequently extracted for orthodontic treatment.[2] Retraction of the anterior teeth is likely required following premolar extraction, resulting in noticeable changes in the anterior soft-tissue profile.

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Patients are often hesitant to undergo extractions, and clinicians try to avoid them; however, in certain cases, extractions are necessary. In patients with vertical growth patterns, the "drawbridge" or "de-wedging" effect of premolar extraction can reduce the vertical skeletal dimension, potentially conferring a clinical benefit.[3-5] However, possible effects of such treatment on the lips must also be considered. Studies examining incisor retraction and soft tissue changes have reported varying outcomes, suggesting that multiple factors influence the lip response.[6-12]

Lip competence also influences soft-tissue positions. It refers to the ability of the lips to maintain a seal at rest and is an important factor that can significantly affect soft-tissue positions.[13] Moreover, some researchers have shown that lip retraction is significantly more pronounced in patients with incompetent lips.[14]

Although studies have evaluated the profile according to vertical growth patterns, none have assessed soft tissue changes in the closed-lip position, which reflects how the lips are affected when maintaining a lip seal after orthodontic treatment involving extractions.

The craniofacial skeletal pattern is another factor influencing the soft tissue profile.[15,16] While differences in soft tissue thickness among various skeletal classifications have been documented,[17-19] the influence of vertical growth pattern on soft tissue changes following incisor retraction is not well established.

Therefore, this study aimed to evaluate the effects of incisor retraction on the closed-lip soft-tissue profile in patients with different vertical growth patterns and assess the role of lip competence in these changes. We hypothesized that the vertical growth pattern and lip competence significantly influence soft tissue changes following incisor retraction.

METHODS

The study protocol received approval from the Marmara University Non-Drug and Non-Medical Device Research Ethics Committee (approval no: 09.2024.673, date: 17.05.2024). A retrospective review of all electronic patient records from the Department of Orthodontics, Marmara University Faculty of Dentistry, was conducted for the period January 2008 to January 2023.

Inclusion criteria were non-growing patients (cervical vertebral maturation index stage 6, age ≥17) with no craniofacial anomalies or history of orthognathic surgery, who had class I or class II molar relationships and completed orthodontic treatment with extraction of two maxillary first premolars or four first premolars (two maxillary and two mandibular). All patients were treated with 0.018-inch slot Roth prescription Gemini brackets (3M Unitek, Monrovia, CA, USA). Initial space closure was performed with t-loops to distalize the canines segmentally. After completion of canine distalization, all posterior teeth were consolidated with a continuous figure-eight ligature. Retraction of the maxillary incisors was then carried out using 0.017×0.025-inch titanium-molybdenum alloy retraction arches. Pre-treatment (T0) and post-treatment (T1) lateral cephalometric radiographs were obtained with the lips closed. Patients with initial crowding ≥8 mm, >2° change in mandibular plane angle (SN-GoMe) during treatment, or any cosmetic procedure during treatment were excluded.

All cephalometric tracings and measurements were performed by a single investigator (E.B.) to ensure consistency. Intra-rater reliability was assessed by re-evaluating 20% of the sample after a two-week interval. Method error was calculated using Dahlberg's formula, and systematic error was evaluated using paired statistical tests. No statistically significant systematic error was detected (p>0.05).

The sample was divided into two groups based on the Frankfort-mandibular plane angle (FMA): patients with FMA >30° were classified as having a high vertical pattern (HVP) (n=49, mean age 24.2 years) and those with FMA ≥22° and ≤30° were classified as having a normal vertical growth pattern (NVP) (n=30, mean age 22.4 years). Patients with FMA <22° were not included in the present study.

For cephalometric analysis, a horizontal reference line, SN-7° (7° below the Sella-Nasion line through Sella), and a vertical line through Nasion perpendicular to it were used as the coordinate system.[20-22] Cephalometric landmarks and reference planes are shown in Figure 1, and variables are defined in Table 1. Lip strain was calculated using Holdaway's method[23] as the difference between basic lip thickness and actual lip thickness with the lips closed (Figure 2).

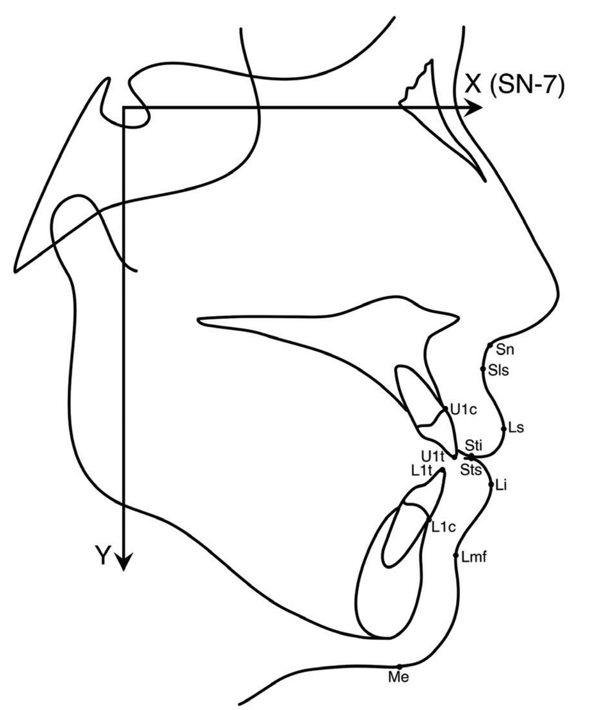

Figure 1. Cephalometric landmarks and reference planes.

Statistical Analysis

The data were analyzed using the statistical software IBM SPSS Statistics 27.0 (IBM Corp., Armonk, New York, USA). Normality of numerical variables was assessed using the Shapiro-Wilk test and Q-Q plots. Categorical variables were presented as frequencies and percentages. Descriptive statistics are given as mean ± standard deviation and median values. A paired-sample t-test was used to compare dependent continuous variables at T0 and T1 when the normality assumption was met; the Wilcoxon signed-rank test was used when it was not. The relationship between dental parameters and the T0-T1 difference in soft tissue parameters for groups NVP, HVP, and total patients was evaluated using Pearson's or Spearman's correlation analysis. A value of $p<0.05$ was considered statistically significant. Linear regression analyses were performed for the NVP and HVP groups to evaluate the associations between the horizontal movement of U1c and L1c and changes in soft-tissue variables, with regression coefficient (B), standard error, standardized beta coefficient, 95% confidence interval, and p-value reported.

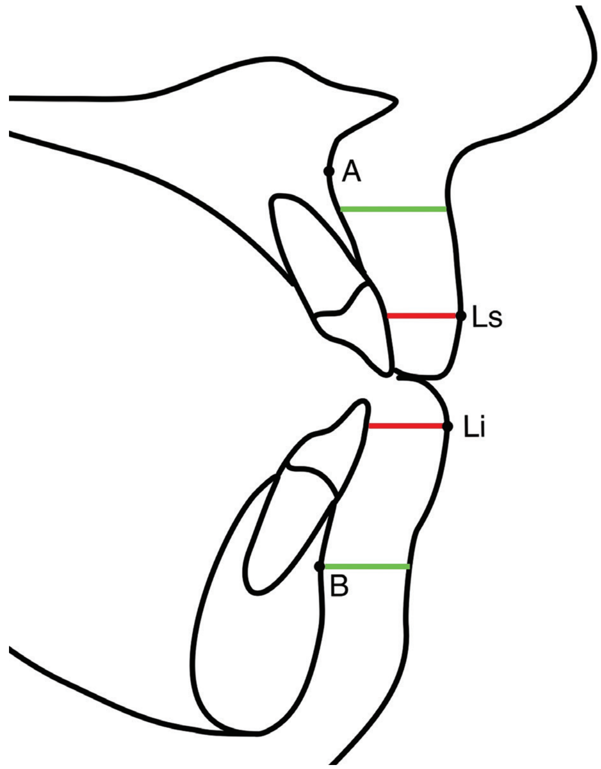

Figure 2. Green lines: Basic lip thickness in the closed lip position; Red lines: Lip thickness in the closed lip position.

RESULTS

There were no statistically significant differences between the HVP and NVP groups in baseline age or sagittal skeletal parameters ($p>0.05$). As expected, vertical skeletal measurements differed between groups due to the predefined classification criteria. The sex distribution across groups did not differ significantly ($p>0.05$).

Table 1. Hard-tissue and soft-tissue variables measured on the lateral cephalometric X-ray

Parameter (mm)	Description
yU1c	Distance from y line to the upper incisor's cervical point
yU1t	Distance from y line to the upper incisor's tip
yL1c	Distance from y line to the lower incisor's cervical point
yL1t	Distance from y line to the lower incisor's tip
ySls	Distance from y line to the deepest point of upper lip
yLs	Distance from y line to the most anterior point of upper lip
xU1c	Distance from x line to the upper incisor's cervical point
xU1t	Distance from x line to the upper incisor's tip
xL1c	Distance from x line to the lower incisor's cervical point
xL1t	Distance from x line to the lower incisor's tip
xSls	Distance from x line to the deepest point of upper lip
xLs	Distance from x line to the most anterior point of upper lip
Ls-U1c	Distance from the most anterior point of upper incisor's cervical point (upper lip thickness)
Sn-Sts	Distance from subnasale to stomion superior (upper lip height)
Upper lip strain	Difference between upper lip thickness and basic upper lip thickness
yLi	Distance from y line to the most anterior point of lower lip
ylmf	Distance from y line to the deepest point of labiomental fold
xLi	Distance from x line to the most anterior point of lower lip
xlmf	Distance from x line to the deepest point of labiomental fold
Li-L1c	Distance from the most anterior point of lower incisor's cervical point (lower lip thickness)
Sti-Me'	Distance from subnasale to stomion superior (lower lip height)
Lower lip strain	Difference between lower lip thickness and basic lower lip thickness

Descriptive statistics of pre- and post-treatment measurements are presented in Table 2. There were no significant changes in the mandibular plane angle during treatment in either the NVP or HVP group (NVP: p=0.184; HVP: p=0.855).

In both groups, the upper incisor cervical points moved significantly posteriorly (~2 mm; p<0.05) and slightly inferiorly. The upper incisor tips also moved posteriorly in both groups, with greater retraction in the HVP group (p<0.001). The cervical points of the lower incisors moved posteriorly in the NVP group (p=0.038). The cervical points of the lower incisors moved slightly downward in the NVP group (p=0.038).

In the HVP group, the upper lip moved 2.86 mm backward (p<0.05) (Table 3). Upper lip thickness increased in both groups after treatment (p<0.05). The labiomental fold moved posteriorly in the NVP group (2.5 mm, p=0.027).

Upper lip height decreased significantly in both groups (HVP: -1.94 mm, NVP: -2.23 mm; p<0.001). The vertical position of the upper lip did not change significantly in either group (HVP: +0.73 mm, p=0.453; NVP: -0.80 mm, p=0.290). Similarly, the vertical position of the lower lip showed no significant change (HVP: +0.47 mm, p=0.509; NVP: -0.31 mm, p=0.757). The vertical position of the labiomental sulcus remained unchanged in both groups.

Upper lip strain decreased significantly in both groups, with a larger reduction in HVP (-3.72 mm) than in NVP (-2.84 mm) (p<0.001 for both). Lower lip strain increased slightly in the HVP group (+0.90 mm, p=0.014).

Correlation coefficients between dental and soft-tissue changes are presented in Table 4. In NVP, horizontal incisor retraction was strongly correlated with the posterior movements of the lower lip and the labiomental fold (correlation coefficients

Table 2. Statistical comparisons by T0-T1 changes in skeletal and dental parameters in NVP and HVP groups

	NVP (n=30)				HVP (n=49)			
	T0	T1	T0- T1 difference	p-value	T0	T1	T0- T1 difference	p-value
Skeletal parameters								
GoMe-SN (°)	37.00 (5.00)	38.00 (5.25)	0.00 (4.00)	0.184⁺	44.77±4.77	44.67±6.22	0.10±3.90	0.855
Dental parameters								
Open bite (mm)	-0.20 (1.78)	1.65 (1.20)	0.00 (4.00)	<0.001⁺	-1.00 (2.30)	1.60 (1.30)	-2.70 (2.50)	<0.001⁺
Upper dental								
x U1c	41.80±4.37	43.27±3.76	-1.47±3.29	**0.021***	45.60±4.98	46.90±4.70	-1.40±4.21	**0.030***
y U1c	67.79±6.70	65.28±5.80	2.51±5.78	**0.024***	67.48±7.38	65.43±7.49	2.06±5.79	**0.017***
x U1It	53.07±4.71	54.07±4.16	-0.99±3.40	0.184*	56.90±5.52	57.63±5.08	-0.82±4.23	0.235*
y U1It	68.41±7.28	65.28±6.38	3.13±6.56	**0.014***	68.10±8.02	64.77±7.91	3.31±6.30	**<0.001***
Lower dental								
x L1t	52.89±4.81	51.94±4.07	0.95±3.58	0.155*	57.20 (6.30)	54.30 (6.00)	2.59±5.62	**<0.001⁺**
y L1t	65.12±7.39	62.55±6.05	2.57±5.14	**0.010***	62.64±7.87	61.35±7.89	1.38±6.13	0.123*
x L1c	61.05±5.77	60.23±4.43	0.83±5.65	0.430*	66.76 (6.58)	62.50 (5.98)	2.42±4.36	**<0.001⁺**
y L1c	63.63±7.63	61.52±6.75	2.11±5.32	**0.038***	60.38±7.82	59.98±8.11	0.52±5.99	0.547*

*Paired sample t test.
⁺Wilcoxon Sign-Rank test.
Values are presented as mean ± standard deviation or median. Bold values indicate statistically significant differences. Statistical significance: p<0.05.
NVP, normal vertical growth pattern; HVP, high vertical growth pattern.

Table 3. Statistical comparisons by T0-T1 changes in soft tissue parameters in NVP and HVP groups

	NVP (n=30)				HVP (n=49)			
Soft tissue parameters	T0	T1	T0- T1 difference	p-value	T0	T1	T0- T1 difference	p-value
Upper lip								
xSls	38.43±4.44	39.00±4.22	-0.57±4.13	0.453*	41.12±4.34	40.73±4.65	0.39±4.29	0.525*
ySls	79.27±6.99	77.07±6.32	2.20±6.56	0.076*	79.22±7.51	77.73±8.03	1.49±6.46	0.114*
xLs	45.60±5.05	46.40±3.76	-0.80±4.04	0.290*	48.79 (7.28)	48.25 (7.23)	0.16 (4.74)	0.453⁺

Table 3. Continued

	NVP (n=30)				HVP (n=49)			
Soft tissue parameters	**T0**	**T1**	**T0- T1 difference**	**p-value**	**T0**	**T1**	**T0- T1 difference**	**p-value**
yLs	81.15±7.46	79.18±7.00	1.97±6.97	0.132*	81.47 (8.76)	78.61 (12.86)	1.84 (6.64)	**0.006**+
Ls-U1c (Upper lip thickness)	12.07±2.17	13.01±2.08	-0.94±2.53	**0.050***	12.20±2.19	13.34±2.52	-1.14±2.50	**0.002***
Sn-Sts (Upper lip height)	23.80±3.50	21.57±3.05	2.23±2.81	**<0.001***	24.24 (4.19)	22.30 (3.95)	1.34±4.05	**<0.001**+
Upper lip strain	-2.84 (3.61)	-1.35 (1.95)	-1.18 (3.14)	**<0.001**+	-3.72 (4.07)	-1.12 (2.49)	-2.51 (4.92)	**<0.001**+
Lower lip & Chin								
xLi	61.97±6.03	62.27±4.78	-0.31±5.37	0.757*	66.06±6.07	65.59±6.15	0.47±4.99	0.509*
yLi	77.52±8.32	75.28±7.39	2.24±6.42	0.066*	75.75±8.34	74.27±9.21	1.48±7.01	0.146*
xLmf	71.04±6.97	71.39±5.62	-0.35±5.58	0.731*	75.47±7.24	75.16±7.32	0.30±4.39	0.631*
yLmf	69.69±8.59	67.19±7.93	2.50±5.88	**0.027***	66.41±8.19	64.76±9.08	1.66±6.97	0.102*
Li_L1c (lower lip thickness)	14.26 (4.85)	15.32 (3.93)	-0.53 (5.08)	0.360+	14.84 (4.35)	15.75 (3.64)	-0.24 (3.37)	0.280+
St-Me ’ (lower lip height)	51.50 (6.45)	51.41 (5.11)	0.30 (6.81)	0.629+	56.00 (7.84)	55.87 (6.95)	1.15 (6.45)	0.117+
Lower lip strain	1.95 (3.21)	2.57 (2.26)	-0.62 (3.62)	0.329+	1.23 (3.70)	2.52 (4.21)	-1.11 (3.72)	0.014+

*Paired sample t test.
+Wilcoxon Sign-Rank test.
Values are presented as mean ± standard deviation or median. Bold values indicate statistically significant differences. Statistical significance: p<0.05.
NVP, normal vertical growth pattern; HVP, high vertical growth pattern.

Table 4. Relationship between dental parameters and soft tissue parameters T0-T1 difference for group HVP and NVP

HVP							
Dental parameters	**Soft tissue parameters**						
	Upper lip					**Lower lip & Chin**	
	Variables		**yLs***	**Ls-U1c+**	**Sn-Sts***	**Upper lip strain+**	**Lower lip Strain+**
Upper dental	xU1c+	r	0.164	0.223	0.156	0.026	0.179
		p-value	0.259	0.123	0.285	0.858	0.218
	yU1c*	r	0.850	0.299	0.355	0.002	-0.030
		p-value	**<0.001**	**0.039**	**0.013**	0.989	0.838
	y U1t*	r	0.813	0.196	0.307	-0.041	-0.001
		p-value	**<0.001**	0.177	**0.032**	0.777	0.995
Lower dental	x L1t*	r	0.261	0.107	0.226	-0.009	-0.024
		p-value	0.070	0.466	0.118	0.951	0.868
	x L1c*	r	0.293	0.166	0.242	-0.088	0.113
		p-value	**0.041**	0.255	0.094	0.546	0.438
NVP	Variables		-	Ls-U1c+	Sn-Sts+	Upper lip strain*	ylmf+
Upper dental	xU1c	r	-	0.290	0.563	-0.082	0.536
		p-value	-	0.120	**0.001**	0.669	**0.002**
	yU1c	r	-	0.140	0.619	-0.250	0.900
		p-value	-	0.462	**<0.001**	0.182	**<0.001**
	yU1t	r	-	0.081	0.575	-0.378	0.892
		p-value	-	0.669	**<0.001**	**0.039**	**<0.001**
Lower dental	yL1t	r	-	0.124	0.410	-0.254	0.936
		p-value	-	0.513	**0.025**	0.175	**<0.001**
	yL1c	r	-	0.097	0.384	-0.267	0.950
		p-value	-	0.609	**0.036**	0.154	**<0.001**

+Pearson correlation coefficients; *Spearman correlation coefficients. Bold values indicate statistically significant differences. Statistical significance: p<0.05.
NVP, normal vertical growth pattern; HVP, high vertical growth pattern.

Table 5. Regression models for the horizontal movement of U1c and soft-tissue variables in NVP and HVP groups

NVP	Unstandardized coefficients		Standardized coefficients	Variation (mm) with each mm of yU1c movement	p-value	95% CI for B
Variables	B	SE	Beta			
yLs	0.805	0.062	0.925	0.855	**<0.001**	0.679; 0.931
yLi	0.864	0.062	0.933	0.870	**<0.001**	0.738; 0.991
SnSts	1.215	0.234	0.695	0.482	**<0.001**	0.737; 1.693
Ls-U1c	-0.057	0.433	-0.024	0.001	0.897	-0.943; 0.830
Upper lip strain	-0.876	0.340	-0.432	0.187	**0.015**	-1.570; -0.181
HVP						
yLs	0.629	0.062	0.827	0.685	**<0.001**	0.503; 0.754
yLi	0.806	0.047	0.929	0.863	**<0.001**	0.712; 0.901
SnSts	0.358	0.205	0.246	0.061	0.088	-0.055; 0.771
Ls-U1c	0.370	0.320	0.166	0.028	0.255	-0.275; 1.014
Upper lip strain	-0.243	0.234	-0.150	0.022	0.304	-0.713; 0.227

Bold values indicate statistically significant differences. Statistical significance: $p<0.05$.
NVP, normal vertical growth pattern; HVP, high vertical growth pattern; CI: confidence interval.

Table 6. Regression models for the horizontal movement of L1c and soft-tissue variables in NVP and HVP groups

NVP Variables	Unstandardized coefficients		Standardized coefficients	Variation (mm) with each mm of yL1c movement	p-value	95% CI for B
	B	SE	Beta			
yLi	0.772	0.063	0.916	0.840	**<0.001**	0.679; 0.931
Li-L1c	0.014	0.086	0.030	0.001	0.874	-0.163; 0.190
ylmf	0.858	0.048	0.957	0.917	**<0.001**	0.760; 0.957
Sti-Me'	0.241	0.099	0.412	0.170	0.021	0.038; 0.443
Lower lip strain	-0.005	0.080	-0.011	0.000	0.955	-0.168; 0.159
HVP						
yLi	0.791	0.041	0.942	0.888	**<0.001**	0.709; 0.873
Li-L1c	0.122	0.335	0.052	0.003	0.718	-0.552; 0.796
ylmf	0.779	0.045	0.928	0.862	**<0.001**	0.689; 0.870
Sti-Me'	0.092	0.099	0.133	0.018	0.358	-0.107; 0.290
Lower lip strain	-0.430	0.319	-0.191	0.037	0.184	-1.071; 0.211

Bold values indicate statistically significant differences. Statistical significance: $p<0.05$.
NVP, normal vertical growth pattern; HVP, high vertical growth pattern; CI: confidence interval.

~0.9). In HVP, upper lip retraction was strongly correlated with maxillary incisor retraction (r ~0.8). Results of the regression analysis are presented in Tables 5 and 6.

DISCUSSION

Extraction of premolars and retraction of anterior teeth are known to affect the facial profile, but growth status and skeletal patterns can modulate the soft tissue response.[24-27] To isolate the effects of tooth movement, we included only non-growing adult patients in this study, eliminating growth-related changes.[28,29]

In the present study, patients were not subdivided according to extraction pattern, as the primary objective was to evaluate the influence of vertical growth pattern on soft tissue response. This approach is supported by the findings of Albertini et al.,[30] who reported that extraction pattern did not significantly influence soft tissue profile changes following premolar extraction therapy.

Previous studies have often used the incisal tip or soft-tissue points to assess tooth-lip relationships. However, some findings suggest that measurements at the incisor's cervical point may better capture the effect of tooth movement on upper lip position.[29,31] Ramos et al.[32] found a significant correlation between upper lip retraction and retraction of the upper incisor's cervical point. Hayashida et al.[33] similarly reported significant correlations between upper lip movement and upper incisor retraction. In our study, we evaluated both the incisal tip and the cervical point of the incisors as reference landmarks for tooth movement, since lower lip position can also be influenced by the upper incisal tip position.[34]

In our study, the backward movement of the upper teeth at the cervical level was found to be statistically significant in both the HVP (2.05 mm) and NVP (2.51 mm) groups. Qadeer et al.[14] conducted a comparative analysis of groups with competent and incompetent lips in their premolar extraction study, revealing a 1.4 mm retraction in the competent group, whereas the incompetent group exhibited a retraction of 3.39 mm. The reason for the incompetency in their group may be an increased proclination of the incisors; thus, they might require more retraction. In our study, both groups exhibited lip incompetence, and a similar degree of retraction (1.47 mm in the HVP group and 1.40 mm in the NVP group) was observed.

In the HVP group, upper lip retraction (2.86 mm) was statistically significant, whereas in the NVP group, upper lip retraction (1.97 mm) was not statistically significant. This difference in soft tissue response might be attributable to differences in lip strain between the groups. Fang et al.[35] observed that patients with lip incompetence experience greater retraction of the lips after incisor retraction than those with competent lips. The HVP group in our study had higher initial lip strain (greater lip incompetence) than the NVP group. This higher initial lip strain likely contributed to the greater retraction of the upper lip observed in the HVP group.

The only soft-tissue vertical dimension that changed significantly was upper-lip height, which decreased in both groups. This likely reflects improved lip competence: patients who initially had lip separation at rest could comfortably close their lips after treatment, thereby effectively shortening the upper lip at rest. However, because all cephalograms were taken with the lips closed, these vertical changes should be interpreted cautiously. The initial closed-lip position at T0 required some patients to stretch their lips; thus, the measured reduction in Sn-Sts primarily indicates a reduction in lip strain rather than true tissue shortening.

We also observed that upper lip thickness increased after treatment in both groups, while changes in lower lip thickness were minimal and not significant. These outcomes are consistent with the reduction in lip strain; at T0, some patients' lips were stretched thin to achieve closure, and after treatment, the lips relaxed and became slightly thicker. This also suggests that the upper lip undergoes greater elongation and thinning than the lower lip to achieve a lip seal in patients with lip incompetence.

Although there were no skeletal vertical changes in our patients, lip strain decreased after incisor retraction. This suggests that the improved lip seal was due to dental changes rather than alterations in vertical skeletal dimensions. Lee et al.[36] similarly found that the inclination and anteroposterior position of maxillary incisors affected upper lip strain more than the vertical skeletal pattern.

In our study, the labiomental sulcus deepened significantly with incisor retraction in the NVP group, whereas no significant change occurred in the HVP group. This is in line with Baek et al.[37] found that younger patients with more elastic soft tissue show greater fold deepening after retraction, whereas patients with less elasticity show minimal change. The higher initial lip strain in the HVP group suggests reduced soft tissue elasticity, which could explain the limited change in their labiomental fold.

Several studies have quantified soft tissue response relative to incisor retraction.[32,33,36,37] In our study, the ratio of upper incisor retraction at the cervical point to upper lip retraction was approximately 1:0.85 in NVP and 1:0.68 in HVP; the lower lip response was about 1:0.86 in both groups. Thus, the upper lip showed a greater change per unit of incisor retraction in the NVP group than in the HVP group. In HVP patients, the upper lip may initially have been stretched and thinned to ensure closure; when lip strain was relieved after retraction, the lip became shorter and thicker, possibly shifting slightly forward. This would reduce the net posterior movement of the upper lip in HVP patients compared with that in NVP patients.

The morphology of the labiomental fold is a prominent aesthetic feature of the facial profile that often captures the attention of observers assessing the lower face.[38] As its position and movement are influenced by various anatomical factors, understanding these relationships is essential. In our study, within the NVP group, a strong positive correlation was found between the horizontal displacement of the labiomental fold and the horizontal movements of both the cervical point and the incisor tip. However, regression analysis (Tables 5 and 6) revealed that despite this correlation, the horizontal position of the labiomental fold was more significantly influenced by other factors, such as the horizontal movement of the lower lip, than by the cervical point or the incisor tip. A similar pattern was observed in the HVP group, where the horizontal position of the labiomental fold was predominantly influenced by the movement of the lower lip, although the cervical point and incisor tip were also somewhat correlated. These findings are particularly relevant in the context of facial aesthetics. A deeper labiomental fold may enhance attractiveness in individuals with increased lower anterior facial height, as it helps deemphasize that lower facial height. Conversely, a shallower fold may be preferred in individuals with shorter faces, as a deeper fold could further accentuate facial shortness.[38] In our study, both groups exhibited greater posterior displacement of the labiomental fold relative to the lower lip, leading to its deepening. This change may contribute to an improvement in aesthetic outcomes, particularly for individuals in the HVP group.

Study Limitations

In the present study, no formal correction for multiple comparisons was applied to secondary analyses; this may increase the risk of type I error. Additionally, soft tissue changes were evaluated using two-dimensional lateral cephalometric radiographs obtained in a closed-lip position. Two-dimensional imaging does not fully capture the three-dimensional behavior and volumetric changes of the soft tissues. Therefore, the findings should be interpreted within the limitations inherent to two-dimensional assessment. Future studies using radiation-free stereophotogrammetric techniques capable of capturing images in both open- and closed-lip positions may offer a more comprehensive assessment of soft tissue responses.

CONCLUSION

In patients with a HVP, upper lip retraction following incisor retraction was significantly greater than in patients with a NVP. Upper lip strain was reduced in both groups after treatment, with a more pronounced reduction in the HVP group. The labiomental sulcus deepened significantly in the NVP group, and strong correlations were observed between lower incisor retraction and changes in the labiomental sulcus. A stronger correlation between maxillary incisor retraction and upper lip retraction was observed in the NVP group than in the HVP group. These findings suggest that the vertical growth pattern should be considered when planning the degree of incisor retraction to achieve the desired soft-tissue profile changes without adversely affecting facial aesthetics.

Ethics

Ethics Committee Approval: The study protocol received approval from the Marmara University Non-Drug and Non-Medical Device Research Ethics Committee (approval no: 09.2024.673, date: 17.05.2024).

Informed Consent: Written and informed consents were previously signed by the participants.

Footnotes

Author Contributions: Concept – B.E., E.B.; Design – B.E., E.B.; Data Collection and/or Processing – B.E., E.B.; Analysis and/or Interpretation – B.E., E.B., B.Em,;Literature Search – B.E., E.B.; Writing – B.E.

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