Extraction versus non-extraction orthodontic treatment: Soft tissue profile changes in borderline class I patients

Ekstrakcyjne a nieekstrakcyjne leczenie ortodontyczne – zmiany profilu tkanek miękkich u pacjentów z wątpliwą klasą I

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Abstract

Background. The decision regarding the selection of extraction or non-extraction orthodontic treatment is a common challenge in orthodontic treatment planning.

Objectives. The objective of this study was to compare the effects of extraction and non-extraction orthodontic treatment on the soft tissue profile of borderline class I patients.

Material and methods. In this retrospective study, 70 patients were selected from among those referred to the Department of Orthodontics of the Faculty of Dentistry at Hamadan University of Medical Sciences in Iran. The inclusion criteria were skeletal class I, 4–10 mm of space deficiency, and the possibility of applying both extraction and non-extraction orthodontic treatment. All patients underwent fixed orthodontic treatment with the use of 0.022-inch-slot edgewise brackets. The patients were divided into 2 groups ($n = 35$) according to the 4-premolar extraction or non-extraction treatment plan. The 2 groups were compared by means of the cephalometric analysis.

Results. There were 11 males and 24 females at a mean age of 17.46 years in the non-extraction group, and 9 males and 26 females at a mean age of 18.46 years in the extraction group. The upper and lower incisors as well as the lower lip moved forward in the non-extraction group (lower lip to E-plane = 0.87 ± 1.39 mm, U1–SN = $2.83 \pm 8.03^\circ$, IMPA = $4.64 \pm 5.47^\circ$). The incisors and the lips moved backward in the extraction group (upper lip to E-plane = -1.42 ± 2.08 mm, lower lip to E-plane = -1.56 ± 1.97 mm, U1–SN = $-7.63 \pm 9.02^\circ$, IMPA = $-7.05 \pm 6.79^\circ$). The differences were statistically significant ($p < 0.05$). Mentolabial sulcus became more pronounced in the non-extraction group (1.92 ± 2.73 mm; $p < 0.001$) and shallower in the extraction group (-1.90 ± 4.2 mm; $p = 0.000$).

Conclusions. Orthodontic treatment can change the soft tissue appearance of the lower third of the face. The lips and the incisors moved forward in the non-extraction group and backward in the extraction group.

Key words: tooth extraction, orthodontics, cephalometry, Angle class I malocclusion

Słowa kluczowe: ekstrakcja zęba, ortodoncja, cefalometria, wada zgryzu klasy I wg Angle'a

Introduction

A large number of people seek orthodontic treatment to improve their dentofacial appearance.¹ In general, the purpose of orthodontic treatment is to improve dentofacial appearance, oral function and the stability of the dental arches. Choosing an appropriate treatment plan helps to maintain a balance between the 3 above-mentioned parameters.^{2–4}

The decision regarding the creation of space is challenging in orthodontic treatment planning. In patients with the tooth size–arch size discrepancy, it is necessary to provide sufficient space for the teeth during orthodontic treatment. The conventional methods for creating the space include the distal movement of the posterior teeth, changes in the width and shape of the arch, the interproximal reduction of the teeth, the protrusion of the incisors, and tooth extraction. Tooth extraction may be required to achieve a coordinated dental arch, compensate moderate to severe dental protrusion or crowding, and camouflage mild to moderate jaw discrepancies.¹ The decision regarding tooth extraction depends on different factors, such as esthetic considerations, the stability of the teeth, and the preferences of patients or orthodontists.⁵

Non-extraction orthodontic treatment is indicated in patients with space excess or dental retroclination. In contrast, in the case of space shortage or dental proclination, the only treatment option is tooth extraction. The treatment plan in such orthodontic patients is relatively straightforward. In addition, post-treatment outcomes in such patients are highly predictable. However, there are some patients for whom both extraction and non-extraction orthodontic treatment can be considered. In such patients, the choice of treatment depends on several factors, and the treatment plan may vary, depending on the patient's soft and hard tissue components, and the preferences of orthodontists and patients. The choice of the treatment plan in these patients is considered to be borderline. No consensus has been reached regarding the effects of tooth extraction on the vertical dimension, facial profile changes, jaw position, temporomandibular joint health, and the periodontal status after treatment.^{6,7}

The perspectives of patients and orthodontists regarding an ideal soft tissue profile have been continuously changing over the past decades.⁸ Tooth extraction can change the soft tissue profile. However, there is controversy regarding the long-term effects of tooth extraction.⁹ Although some studies have been conducted on this topic, no study could reach a definite conclusion regarding the effect of treatment on the appearance of the lower third of the face.^{8,10–12} A limited number of available studies on this topic include borderline patients. The results may be overestimated or underestimated, depending on whether the chosen patients had space shortage or excess, or dental protrusion.

The primary objective of this study was to evaluate and compare the effects of extraction and non-extraction

orthodontic treatment on the soft tissue profile of borderline class I patients.

Material and methods

In this retrospective study, cephalometric changes that occurred during the orthodontic treatment of the patients treated with extraction and non-extraction methods were evaluated. The patients were randomly selected from among those reporting to the Department of Orthodontics of the Faculty of Dentistry at Hamadan University of Medical Sciences in Iran.

The inclusion criteria were as follows: age between 18 and 30 years, skeletal class I relationship ($1^\circ < \text{ANB} < 5^\circ$), space deficiency of 4–10 mm, and the borderline treatment plan – the possibility of both extraction and non-extraction treatment.

The exclusion criteria were the following: patients with craniofacial deformities or syndromes, large discrepancies in the tooth size, a history of unsuccessful orthodontic or orthognathic treatment, a history of facial surgeries, an intake of medications that would affect the soft tissue volume.

In order to choose borderline patients, 6 factors were assessed according to Paquette et al.¹³: (1) the magnitude of space deficiency in the maxillary arch; (2) the magnitude of space deficiency in the mandibular arch; (3) maxillary incisor protrusion (U1–SN); (4) mandibular incisor protrusion (L1–NB); (5) the irregularity index; and (6) facial convexity (Z-angle).

Afterward, 3 orthodontists were asked to design the treatment plan according to the 6 above-mentioned factors. The patients were categorized in the borderline range in case of disagreement between the orthodontists regarding the selection of the extraction or non-extraction orthodontic treatment plan.

The sample size was calculated to be 34 in each group according to a previous study,¹ assuming a power of 0.85, type I error of 0.05, standard deviation (SD) of 1.2, and with the aim of finding a 0.5-millimeter true difference between the groups, using Power and Sample Size Calculator v. 3.1.2 (<https://ps-power-and-sample-size-calculation.software.informer.com/3.1/>).

The primary (baseline) and final cephalograms, casts and photographs of the patients were examined for space deficiency, and the soft tissue profile analysis was performed for case selection. All patients had been treated with 0.022-inch-slot edgewise brackets, and had complete pre-treatment and post-treatment diagnostic records.

The eligible patients were categorized as follows:

- the non-extraction group included patients who underwent non-extraction orthodontic treatment (except third molar extraction);
- the extraction group included patients who were treated with the extraction of the 4 first or second premolars.

The pre-treatment and post-treatment cephalograms were analyzed using the Dolphin Imaging software v. 11.8 (Patterson Dental Supply, Inc., St. Paul, USA). Thirty-seven landmarks were assessed (23 hard tissue and 14 soft tissue landmarks) (Fig. 1). Linear and angular measurements were made to evaluate the soft and hard tissue profiles of the patients (Table 1).

In order to assess the intra-class correlation coefficient, 11 cephalograms were traced by another calibrated researcher.

The data was analyzed using PASW Statistics for Windows v. 18 (SPSS, Inc., Chicago, USA). The paired *t* test was used to analyze changes in each treatment group, and the independent *t* test was utilized to compare the 2 kinds of treatment in the 2 groups. Pearson's correlation coefficient was used to assess the correlation of hard tissue and soft tissue changes. A *p*-value of <0.05 was considered statistically significant.

Fig. 1. Hard tissue and soft tissue cephalometric landmarks used for cephalometric tracing

Table 1. Linear and angular cephalometric measurements and their definitions

No.	Variable	Definition
1	nasolabial angle (Col–Sn–UL)	angle between the line tangent to the columella and the line tangent to the upper lip
2	E-plane	line passing through the tip of the nose and soft tissue pogonion
3	upper lip to E-plane	distance of the most anterior point of the upper lip to E-plane
4	lower lip to E-plane	distance of the most anterior point of the lower lip to E-plane
5	upper lip thickness	horizontal distance between the most anterior point of the upper lip and the labial surface of the upper central incisors
6	lower lip thickness	horizontal distance between the most anterior point of the lower lip and the labial surface of the lower central incisors
7	upper lip length	the shortest distance between subnasale and the most inferior point of the upper lip vermillion
8	lower lip length	the shortest distance between soft tissue menton and the most superior point of the lower lip vermillion
9	mentolabial sulcus	the shortest distance between the most posterior point in the lower lip contour (soft tissue B point) and the line passing through soft tissue pogonion and the most anterior point of the lower lip
10	Wits appraisal	distance between the points resulting from drawing perpendicular lines from A and B points to the functional occlusal plane
11	post.–ant. face height (S–Go / N–Me)	proportional ratio between the posterior facial height (S to gonion) and the anterior facial height (N to menton)
12	UFH / TFH (N–ANS / N–Me)	proportional ratio between the upper anterior facial height (N to ANS point) and the total anterior facial height (N to menton)
13	posterior facial height (S–Go)	distance between S and gonion
14	anterior facial height (N–Me)	distance between N and menton
15	upper face height (N–ANS)	distance between N and ANS point
16	Pog–NB	distance between pogonion and the line passing through N and B points
17	SN–GoMe	angle between SN line and the mandibular plane (gonion to menton line)
18	U1–SN	angle between the long axis of the most prominent upper incisors and SN line
19	interincisal angle	angle between the long axis of the upper and lower incisors
20	IMPA (L1–MP)	angle between the long axis of the most prominent lower incisors and the mandibular plane (gonion to menton line)
21	FH–SN	angle between Frankfort and SN lines
22	SNA	angle between S, N and A points
23	SNB	angle between S, N and B points
24	ANB	angle between A, N and B points
25	interlabial gap	vertical distance between the most inferior point of the upper lip vermillion and the most superior point of the lower lip vermillion

Results

This study was performed on 70 patients, including 35 patients in the extraction group (11 males and 24 females) and 35 patients in the non-extraction group (9 males and 26 females). The mean age of the patients at the onset of treatment was 17.45 ± 4.66 years and 18.46 ± 4.94 years in the non-extraction and extraction groups, respectively. The mean intra-class correlation coefficient was 0.79.

Tables 2 and 3 show the pre-treatment and post-treatment values of cephalometric variables in the non-extraction and extraction groups, respectively.

In the non-extraction group, changes in lower lip to E-plane ($p \leq 0.001$), mentolabial sulcus ($p \leq 0.001$), SN-GoMe ($p \leq 0.035$), U1-SN ($p \leq 0.044$), interincisal angle ($p \leq 0.001$), and IMPA ($p \leq 0.001$) were all statistically significant.

In the extraction group, nasolabial angle ($p \leq 0.048$), upper lip to E-plane ($p \leq 0.001$), lower lip to E-plane ($p \leq 0.001$), mentolabial sulcus ($p \leq 0.012$), Pog-NB ($p \leq 0.047$), U1-SN ($p \leq 0.001$), interincisal angle ($p \leq 0.001$), and IMPA ($p \leq 0.001$) changed significantly after treatment.

Table 4 compares the changes between the extraction and non-extraction treatment groups.

The comparison of the 2 groups revealed significant differences in the upper lip to E-plane, lower lip to E-plane, mentolabial sulcus, U1-SN, interincisal angle, and IMPA (Table 4).

Significant differences were noted between the extraction and non-extraction treatment groups regarding the change in the position of the upper and lower incisors and the lips, all moving backward in the extraction group. The upper and lower incisors and the lower lip moved forward in the non-extraction treatment group. Mentolabial sulcus became shallower in the non-extraction group and more pronounced in the extraction group.

Tables 5 and 6 show the results of Pearson's correlation test regarding the correlation between skeletal/dental changes and soft tissue changes.

As shown in Tables 5 and 6, the posterior and anterior facial height had a significant correlation with the upper and lower lip length and the mentolabial sulcus depth in both groups and with the upper lip thickness in the extraction group. The parameter Pog-NB had an inverse correlation with lower lip to E-plane in the extraction group, while there was a positive correlation between this parameter and the lower lip length, and U1-SN had a moderately positive correlation with the upper lip thickness and the mentolabial sulcus depth in the non-extraction group. The parameter IMPA positively correlated with the upper lip thickness and the mentolabial sulcus depth in the extraction group.

Table 2. Pre-treatment and post-treatment values of the variables in the non-extraction group

No.	Variable	Before treatment	After treatment	p-value
1	nasolabial angle (Col-Sn-UL) [°]	107.81 ± 10.38	107.02 ± 9.84	0.676
2	upper lip to E-plane [mm]	-3.20 ± 2.16	-3.20 ± 2.01	0.992
3	lower lip to E-plane [mm]	-0.37 ± 2.12	0.50 ± 2.33	0.001*
4	upper lip thickness [mm]	4.53 ± 1.07	4.64 ± 1.19	0.645
5	lower lip thickness [mm]	4.55 ± 1.12	4.76 ± 1.17	0.574
6	upper lip length [mm]	20.19 ± 2.50	19.84 ± 3.30	0.439
7	lower lip length [mm]	17.05 ± 3.14	17.09 ± 2.77	0.943
8	mentolabial sulcus [mm]	7.52 ± 3.87	9.44 ± 4.43	0.001*
9	Wits appraisal [mm]	2.18 ± 3.41	2.00 ± 2.53	0.129
10	post.-ant. face height (S-Go / N-Me)	63.73 ± 3.37	63.86 ± 3.64	0.757
11	UFH / TFH (N-ANS / N-Me)	44.28 ± 1.98	44.50 ± 2.11	0.401
12	posterior facial height (S-Go) [mm]	70.11 ± 8.53	70.54 ± 10.39	0.776
13	anterior facial height (N-Me) [mm]	121.62 ± 12.71	123.17 ± 15.80	0.533
14	upper face height (N-ANS) [mm]	47.76 ± 5.34	48.59 ± 6.13	0.427
15	Pog-NB [mm]	1.48 ± 1.29	1.46 ± 1.46	0.929
16	SN-GoMe [°]	34.06 ± 4.50	35.21 ± 4.74	0.035*
17	U1-SN [°]	102.91 ± 7.17	105.74 ± 6.85	0.044*
18	interincisal angle [°]	125.15 ± 10.37	116.55 ± 9.44	0.001*
19	IMPA (L1-MP) [°]	95.08 ± 6.00	99.72 ± 6.87	0.001*
20	FH-SN [°]	7.36 ± 3.02	6.96 ± 3.18	0.467
21	SNA [°]	82.31 ± 4.59	81.68 ± 4.38	0.265
22	SNB [°]	76.84 ± 3.04	77.00 ± 3.11	0.694
23	ANB [°]	4.47 ± 2.54	4.69 ± 2.35	0.115
24	interlabial gap [mm]	2.09 ± 1.53	1.95 ± 0.67	0.594

Data presented as mean (M) $\pm$ standard deviation (SD).

* statistical significance.

Table 3. Pre-treatment and post-treatment values of the variables in the extraction group

No.	Variable	Before treatment	After treatment	p-value
1	nasolabial angle (Col-Sn-UL) [°]	107.12 ±13.75	111.15 ±11.28	0.048*
2	upper lip to E-plane [mm]	-2.27 ±2.06	-3.69 ±2.05	0.001*
3	lower lip to E-plane [mm]	0.80 ±2.25	-0.76 ±2.08	0.001*
4	upper lip thickness [mm]	4.40 ±1.15	4.55 ±1.10	0.674
5	lower lip thickness [mm]	4.43 ±1.63	4.62 ±1.53	0.703
6	upper lip length [mm]	19.84 ±3.52	20.00 ±3.25	0.806
7	lower lip length [mm]	16.66 ±3.22	17.29 ±2.68	0.312
8	mentolabial sulcus [mm]	9.04 ±5.42	7.14 ±3.56	0.012*
9	Wits appraisal [mm]	1.63 ±3.52	1.19 ±3.32	0.434
10	post.-ant. face height (S-Go / N-Me)	62.72 ±3.48	63.40 ±3.64	0.193
11	UFH / TFH (N-ANS / N-Me)	44.00 ±2.08	43.94 ±1.96	0.806
12	posterior facial height (S-Go) [mm]	69.27 ±10.99	71.80 ±9.28	0.245
13	anterior facial height (N-Me) [mm]	121.26 ±17.78	125.98 ±14.76	0.212
14	upper face height (N-ANS) [mm]	47.25 ±6.70	49.09 ±5.61	0.218
15	Pog-NB [mm]	0.86 ±1.21	1.24 ±1.21	0.047*
16	SN-GoMe [°]	35.05 ±5.15	35.96 ±5.54	0.057
17	U1-SN [°]	105.96 ±7.59	98.33 ±9.04	0.001*
18	interincisal angle [°]	119.76 ±11.43	133.39 ±8.29	0.001*
19	IMPA (L1-MP) [°]	96.22 ±6.90	89.17 ±7.26	0.001*
20	FH-SN [°]	7.34 ±3.35	7.06 ±3.41	0.647
21	SNA [°]	81.32 ±3.53	81.21 ±3.87	0.798
22	SNB [°]	76.89 ±3.14	76.76 ±4.05	0.692
23	ANB [°]	4.43 ±2.71	4.46 ±2.50	0.947
24	interlabial gap [mm]	2.28 ±2.07	2.13 ±1.18	0.648

Data presented as mean (M) ± standard deviation (SD).

* statistical significance.

Table 4. Comparison of the treatment changes between the extraction and non-extraction groups

Parameter	Group	M	SD	p-value
nasolabial angle (Col-Sn-UL) [°]	non-extraction extraction	-0.789 4.031	11.05049 11.63786	0.080
upper lip to E-plane [mm]	non-extraction extraction	-0.003 -1.423	1.76993 2.08144	0.003*
lower lip to E-plane [mm]	non-extraction extraction	0.874 -1.569	1.39439 1.97153	0.001*
upper lip thickness [mm]	non-extraction extraction	0.209 0.204	1.28941 1.34009	0.439
lower lip thickness [mm]	non-extraction extraction	0.274 0.191	2.02068 2.61745	0.461
upper lip length [mm]	non-extraction extraction	-0.351 0.166	2.65766 3.96002	0.523
lower lip length [mm]	non-extraction extraction	0.037 0.631	3.03858 3.64206	0.461
mentolabial sulcus [mm]	non-extraction extraction	1.911 -1.891	2.73354 4.20423	0.001*
Wits appraisal [mm]	non-extraction extraction	-1.186 -0.443	3.07630 3.31044	0.334
post.-ant. face height (S-Go / N-Me)	non-extraction extraction	-0.129 -0.671	2.44078 2.98847	0.408
UFH / TFH (N-ANS / N-Me)	non-extraction extraction	0.214 -0.054	1.49098 1.29985	0.425
posterior facial height (S-Go) [mm]	non-extraction extraction	0.431 2.526	8.90640 12.63386	0.426
anterior facial height (N-Me) [mm]	non-extraction extraction	1.557 4.723	14.63691 21.94631	0.480
upper face height (N-ANS) [mm]	non-extraction extraction	0.834 1.843	6.13615 8.68671	0.577
Pog-NB [mm]	non-extraction extraction	-0.014 0.380	0.93969 1.09270	0.110
SN-GoMe [°]	non-extraction extraction	1.157 0.911	3.11847 2.74084	0.727
U1-SN [°]	non-extraction extraction	2.834 -7.631	8.03587 9.02848	0.001*
interincisal angle [°]	non-extraction extraction	-8.603 13.626	11.00036 12.33518	0.001*
IMPA (L1-MP) [°]	non-extraction extraction	4.637 -7.051	5.47379 6.79945	0.001*
FH-SN [°]	non-extraction extraction	-0.397 -0.274	3.19333 3.50466	0.878
SNA [°]	non-extraction extraction	-0.626 -0.117	3.26914 2.68892	0.480
SNB [°]	non-extraction extraction	0.154 -0.131	2.30298 1.94766	0.577
ANB [°]	non-extraction extraction	-0.780 0.029	1.80274 2.50301	0.126
interlabial gap [mm]	non-extraction extraction	-0.146 -0.149	1.60374 1.90593	0.995

M – mean; SD – standard deviation; * statistical significance.

Table 5. Pearson's correlation between skeletal/dental changes and soft tissue changes in the non-extraction group

Changes in parameters	Nasolabial angle (Col-Sn-UL)	Upper lip to E-plane	Lower lip to E-plane	Upper lip thickness	Lower lip thickness	Upper lip length	Lower lip length	Mentolabial sulcus
Posterior facial height (S-Go)	0.022	-0.197	0.251	0.321	-0.088	0.767*	0.464*	0.540*
Anterior facial height (N-Me)	0.062	-0.235	0.122	0.254	-0.081	0.819*	0.554*	0.416*
Pog-NB	0.011	-0.016	0.157	0.097	0.005	0.094	0.309	0.237
U1-SN	-0.289	0.155	0.289	0.441*	0.308	-0.002	0.218	0.385*
IMPA	0.024	-0.012	0.173	-0.022	-0.096	0.147	0.184	0.211

* statistical significance.

Table 6. Pearson's correlation between skeletal/dental changes and soft tissue changes in the extraction group

Changes in parameters	Nasolabial angle (Col-Sn-UL)	Upper lip to E-plane	Lower lip to E-plane	Upper lip thickness	Lower lip thickness	Upper lip length	Lower lip length	Mentolabial sulcus
Posterior facial height (S-Go)	-0.190	-0.275	0.078	0.358*	-0.730	0.895*	0.829*	0.346*
Anterior facial height (N-Me)	-0.258	-0.229	0.169	0.396*	-0.032	0.922*	0.823*	0.411*
Pog-NB	-0.130	-0.225	-0.347*	0.240	0.002	0.324	0.409*	-0.050
U1-SN	-0.085	-0.115	0.005	0.203	0.293	0.048	0.034	0.122
IMPA	-0.156	-0.067	0.229	0.176	0.051	0.382*	0.197	0.369*

* statistical significance.

Discussion

In general, dental and skeletal changes that occur during orthodontic treatment affect the soft tissue structures. Soft tissue changes do not completely coincide with hard tissue changes, and may be greater or lesser depending on the treatment plan.^{5,13–16} The purpose of the present study was to compare the treatment outcomes between the extraction and non-extraction orthodontic treatment groups.

Soft tissue variables

In both the extraction and non-extraction groups, lower lip to E-plane changed significantly. In the extraction group, the lower lip moved backward whereas in the non-extraction group, the lower lip moved forward. In a study by Xu et al., the lower lip moved backward in relation to E-plane in both extraction and non-extraction treatment, but this movement was greater in the extraction group.¹⁷ However, in extraction and non-extraction treatment, the lower lip moved backward and forward in relation to Sn-Pog line (the line passing through subnasale and the chin prominence), respectively. Thus, it seems that the change in the lower lip position was similar to that reported in the present study. The reason for the difference in the results regarding lower lip to E-plane can be attributed to the age range and malocclusion of the patients in the study by Xu et al. In their study, the mean age of patients was 12 years and a mixed group of patients with different malocclusion types was evaluated.¹⁷ Large changes in the nasal lip prominence can make E-line an unstable plane.

In addition, Momeni Danaei et al. examined the skeletal, dental and soft tissue changes following orthodontic treatment with or without tooth extraction in patients with class II division I malocclusion, and reported results similar to the results of the extraction group in the present study.¹⁵ However, in the non-extraction group, the lower lip was not significantly altered. This difference in the outcome is due to the difference in the malocclusion type (class I vs class II). In other words, in class II patients, both extraction and non-extraction treatment caused similar changes in the dental position.¹⁵ These results were similar to those of Bravo.¹⁸ Also, Bishara et al. reported the forward movement of the lower lip during non-extraction treatment.¹⁹

The comparison of the 2 groups revealed that changes in the position of the lower lip in the extraction group were significantly different from those in the non-extraction group, which is similar to the findings of Xu et al.¹⁷

Upper lip to E-plane experienced significant changes in the extraction group. It seems that the upper lip moved backward in the extraction group in our study. This finding is similar to that of Bravo.¹⁸

There was a significant difference between the groups in the position of the upper lip in relation to E-plane in our study. Our results are in contrast to those of Xu et al., which can be attributed to the treatment mechanics.¹⁷

In our study, nasolabial angle in the extraction group significantly increased, which suggests that the upper lip moved backward. This angle decreased very slightly in the non-extraction group after treatment, but the change was not statistically significant and may indicate that the upper lip position did not change significantly.

This finding confirms the results regarding the position of the lips in relation to E-plane. It is also similar to the results of Talass et al.,²⁰ Lo et al.²¹ and Diels et al.²² Changes in this angle did not differ significantly between the 2 groups.

In our study, mentolabial sulcus increased significantly in the non-extraction group after treatment, but decreased significantly in the extraction group. This finding shows that mandibular incisor retroclination in the extraction group can retract the lower lip relative to the sagittal plane. Also, in the non-extraction group, as the mandibular incisors moved forward, the lower lip also moved toward the sagittal plane, causing a deeper mentolabial sulcus.¹ These changes are in line with significant changes in IMPA, which were observed in both groups after treatment. The mentolabial sulcus changes also coincided with the lower lip to E-plane changes. In the non-extraction group, lower lip to E-plane significantly decreased after treatment, which indicated the protrusion of the lower lip. In the extraction group, the distance between the lower lip and E-plane significantly increased, which indicated the retrusion of the lower lip. The mentolabial sulcus changes were different between the 2 groups.

The lip thickness and length did not change in any group. The results of other studies in this regard have been controversial.^{5,9} Such contradictory findings indicate that multiple factors, other than orthodontic treatment, can affect the thickness of the lips, such as age, race and the lip structure.

No significant difference was observed in the interlabial gap in any group. Due to the fact that the patients in this study were in the borderline spectrum, none of them had a severe protrusion or retrusion of the lips. Hence, achieving this finding seems logical.

Skeletal variables

In the anteroposterior aspect, ANB and Wits appraisal did not change significantly in any group. Considering the fact that all patients had class I malocclusion before treatment, this finding appears to be logical.

In the extraction group, Pog–NB significantly increased after treatment. This finding suggests that in the extraction group, the chin seems to be more prominent in the profile view. This variable did not change significantly in the non-extraction group. Although point B is a skeletal point, a change in the position of the teeth can affect the position of this point.²³ The retraction of the lower teeth could retract NB line and make Pog–NB larger in the extraction group.

In the vertical dimension, the posterior and anterior facial height did not change significantly in either group. The only significant change in the vertical dimension was in the mandibular plane and the cranial base angle (SN–GoMe) in the non-extraction group. The measurements showed that this angle increased slightly after treatment in the non-extraction group. However, the linear variables of the vertical facial height did not change significantly.

Dental variables

In the extraction group, U1–SN decreased significantly after treatment, indicating the retraction of the maxillary incisors. This finding is consistent with a significant decrease in upper lip to E-plane in the extraction group. This may indicate that with the retraction of the maxillary incisors, the upper lip also moved backward. The parameter U1–SN significantly increased in the non-extraction group, which caused the upper lip to move forward relative to the sagittal plane. It should be noted that upper lip to E-plane increased in the non-extraction group, but this increase was not large enough to cause a statistically significant change. It also shows that the upper lip changes did not fully coincide with dental changes.

Changes in the upper incisor inclination in the extraction group were significantly different from those in the non-extraction group. The parameter IMPA significantly increased in the non-extraction group, but significantly decreased in the extraction group. This finding is in agreement with the findings regarding lower lip to E-plane. Following the retraction of the incisors, the lower lip moved backward in the extraction group whereas in the non-extraction group, the lower lip moved forward due to the protraction of the incisors. The differences between the 2 treatment groups in the angle between the lower incisors and the mandibular plane were significant.

Interincisal angle increased significantly in the extraction group, which can be attributed to a significant reduction in U1–SN and IMPA in the extraction group. Interincisal angle decreased significantly in the non-extraction group, which explains the maxillary and mandibular incisor protrusion. There was a significant difference between the 2 groups in the interincisal angle variations.

Correlation between the variables

In the present study, the inclination of incisors did not show a strong correlation with the upper lip position. This angle did not have a significant correlation with nasolabial angle, either. In fact, the position of the upper lip was not significantly correlated with any of the evaluated variables. However, the position of the lower lip in relation to E-plane had a significant inverse correlation with Pog–NB in the extraction group. The variable Pog–NB did not have a positive correlation with lower lip to E-plane in the non-extraction group. The lower lip thickness did not have a significant correlation with any of the vertical or dental variables, but the upper lip thickness had a significant positive correlation with the angle of the maxillary incisors (U1–SN) in the non-extraction group as well as with the posterior and anterior facial height in the extraction group. Nasolabial angle did not correlate with any hard tissue variable. This finding is similar to that of Fitzgerald et al.²⁴

Upper lip to E-plane did not have any correlation with the hard tissue variables. However, lower lip to E-plane had an inverse correlation with the chin position (Pog–NB) in the extraction group. As the chin moves forward, E-plane is also displaced forward, increasing the lower lip-to-E-plane distance.

The lower lip thickness did not have any significant correlation with the hard tissue variables. However, the upper lip thickness had a positive correlation with the upper incisor angulation (U1–SN) in the non-extraction group, and the posterior and anterior facial height in the extraction group. Shirvani et al. also revealed a correlation between the incisor angulation and the lip thickness.²⁵ The lip structure and its initial thickness can affect this correlation. Oliver showed that in patients with thicker lips or in people who have lips with low traction, the lips follow hard tissue changes to a lesser degree in comparison with patients with thin lips or high-traction lips.²⁶ A lack of a correlation between the upper lip thickness and the incisor angulation in the extraction group can be attributed to this fact. In addition, Momeni Danaei et al. revealed that, although lip retraction had a correlation with dental retraction, this correlation was not strong.¹⁵ According to Talass et al., the upper lip changes during orthodontic treatment are less predictable, and they can be attributed to the lip anatomy and the complex dynamics of the upper lip.²⁰

In both the extraction and non-extraction groups, a significant positive correlation existed between the vertical facial changes and the upper and lower lip length. It is interesting to note that in both groups, the facial height changes had a stronger correlation with the upper lip than with the lower lip.

In the extraction group, the chin prominence had a positive correlation with the lower lip length. The lower lip length is measured as the distance between soft tissue menton and the most superior point of the lower lip. It seems logical that by increasing the chin prominence, the lower lip length would increase.

The lower incisor angulation had a significant correlation with the upper lip length in the extraction group. It seems that the retraction of the lower incisors decreases the traction of the upper lip, leading to lip shortening.²⁵

There was a significant positive correlation between the facial height and mentolabial sulcus. Mentolabial sulcus had a positive correlation with the angle of the maxillary incisors in the non-extraction group and the angle of the mandibular incisors in the extraction group. This finding is similar to that of Bloom.²⁷

Conclusions

According to the results of the present study, extraction and non-extraction orthodontic treatment has different effects on the soft tissue profile of borderline class I orthodontic patients. In general, skeletal changes were similar

in the 2 groups. The greatest difference was in the lips and the upper and lower incisors. In the patients with the extraction treatment plan, the anterior teeth and the upper and lower lips were retracted relative to the sagittal plane, but in the patients with the non-extraction treatment plan, the anterior teeth and the lower lip moved forward relative to the sagittal plane.

Mentolabial sulcus also became shallower after treatment in the extraction group and deeper in the non-extraction group. Considering these findings along with the patients' facial features can be beneficial to the orthodontic treatment planning of borderline patients.

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