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ORIGINAL ARTICLE

Evaluation of the airway, soft tissue, and hyoid bone position changes following premolar-extraction orthodontic treatment in Class I malocclusion

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Abstract

Background: The soft tissue profile plays a significant role in the appearance of patient and treatment satisfaction, while the airway affects breathing patterns. This study aimed to investigate the impact of premolar extraction on soft tissue profile, airway dimension, and position of the hyoid bone in Class 1 patients.

Materials & Methods: This retrospective analytical study analyzed pre- and post-treatment lateral cephalograms of 27 Class I patients aged 18 to 30 years, referred to Isfahan Islamic Azad University. Each patient received fixed orthodontic treatment that involved the extraction of all four first premolars. The cephalograms were captured in natural head position with the head centered between the X-ray source and the film, both before and after treatment, and traced manually. To assess soft tissue profile, E-line, UL-E line, LL-E line, U1-L1, FCA, ILA, MLA, and HNB were evaluated. For airway and hyoid bone position, S-H, H-RGN, VAL, U-MPW, TB-TPPW, and V-LPW were assessed. Data were analyzed by Paired t-test and Pearson correlation coefficients (α= 0.05).

Results: The values of LL-E line (p=0.006), UL-E line (p=0.001), and the HNB angle (p=0.049) significantly decreased after treatment. Other soft tissue variables showed no significant differences(p>0.05). The airway variables did not show significant differences; however, S-H, which relates to the hyoid bone, showed a significant decrease (p=0.038).

Conclusion: Treatment of Class I patients with first premolar extraction did not change the airway but resulted in the hyoid bone being positioned more superiorly. This treatment also retracted both lips and reduced facial convexity.

Keywords: Orthodontics, Corrective; Cephalometry; Tooth Extraction

Introduction

One of the treatments discussed in orthodontics is the management of cases with or without the extraction of premolars. This is challenging as it impacts various parameters, such as treatment stability, vertical facial height, arch width, and soft tissue and facial dimensions (1).

The pharynx is a multifunctional organ involved in respiration and swallowing, anatomically divided into three parts: nasopharynx, oropharynx, and laryngopharynx (2, 3). The boundaries of the airway include the mandible, hyoid bone, base of the skull, spinal column, and nasal septum. Various studies have

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examined the relationship between the upper airway and the position of the hyoid bone. The hyoid bone is unique as it does not articulate with any other bone in the body, and plays a crucial role in respiratory function by adjusting its position to open the airway (4-6).

The evaluation of the upper airway is very important due to its role in swallowing, breathing, speech articulation, malocclusion, and the stability of orthodontic treatment. Obstruction and narrowing of the upper airway affect breathing, which may lead to developmental changes in craniofacial morphology, such as a deficiency in the width of the maxilla. To achieve normal craniofacial growth and development, early diagnosis and treatment of respiratory disorders are essential. Various studies have been conducted in this area, indicating that orthodontic treatments involving the extraction of premolars may cause narrowing of the airway passage and a reduction in its overall dimensions (7, 8).

The anatomy of the structures surrounding the upper airway can play a significant role in the development of respiratory problems. The hyoid bone is a horseshoe-shaped bone located at the posterior part of the mandible and anterior to the lumbar vertebrae. Cephalometric studies related to the position of this bone have shown a significant correlation regarding its impact on the dimensions of the upper airway space. Additionally, the hyoid bone serves as a conventional landmark for measuring the length of the pharynx and the dimensions of the upper airway (8, 9).

The soft tissue profile is one of the main factors in the diagnosis and treatment planning of orthodontics. Since the primary goal for most patients undergoing orthodontic treatment is to achieve a satisfactory appearance and facial profile, this factor significantly influences the satisfaction and self-confidence of patients. Therefore, specialists should pay particular attention to soft tissue profile factors, including nasal prominence, the position of the upper and lower lips, nasolabial, interlabial, and mentolabial angles, among others. Treatment plans may include the extraction of premolars to create more space for aligning crowded teeth and to camouflage mild skeletal issues (10).

Some specialists believe that the extraction of premolars is associated with the retraction of incisors, which in turn leads to the retraction of the lips. As a result, patients treated with this method tend to have a flatter facial profile compared to those treated with the retention of premolars. However, the flattening of the facial profile, often referred to as "dished in," contradicts aesthetic standards. Recently, there has been a trend among patients towards having a convex facial profile and prominent lips to achieve a younger appearance (11).

The results of the study by Chopra et al (12) indicated that the retraction of incisors in the space of extracted premolars led to a reduction in the dimensions of the airway in the oropharynx and hypopharynx, as well as a posterior-inferior shift in the position of the hyoid bone. In contrast, Maurya et al (13) examined the impact of first premolar extraction on pharyngeal airway and hyoid bone position, finding that in both groups (those treated with and without premolar extraction), no changes were observed in pharyngeal airway or hyoid bone position after treatment.

Despite numerous studies comparing cases with and without premolar extractions, there has been no study evaluating the effect of first premolar extraction in Class I patients on soft tissue profile and changes in upper airway and hyoid bone position simultaneously. Thus, this study aimed to evaluate this relationship in the studied population.

Materials and Methods

In this retrospective analytical study with a pre-post design (ethic code: IR.IAU.KHUISF.REC.1401.28), lateral cephalometric images of 27 Class I patients

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aged 18 to 30 years referred to the department of orthodontics, Islamic Azad University, Isfahan branch, were used. The images were obtained using the Galileos-Sirona device (Bensheim-Germany) with high resolution, exposure conditions of 85-100 kV and 5-7 MAs, total filtration of > 2.5 mm Al, and a scanning time of 14 seconds. The cephalograms were captured in natural head position with the head centered between the X-ray source and the film, both before and after treatment. During the exposure, patients were asked to put their teeth in centric occlusion and to keep their tongue in gentle contact with maxillary incisors. Cephalate with ear rods and nasal support helped keep the head in position. Subsequently, tracings were performed manually on the radiographs. To enhance the accuracy of the measurements, the Digimizer software was used.

Acceptable Images of patients with a Class I molar relationship, with a treatment plan involving the extraction of four first premolars, and fixed orthodontic treatment with incisor retraction were included in the study . Images with congenital absence of teeth (except for third molars), functional appliance treatments, interventional surgery, previous history of sleep apnea, nocturnal snoring, adenoidectomy, tonsillectomy, and pharyngeal diseases were excluded from the study.

Lateral cephalometric images of individuals meeting the study entry criteria were interpreted and analyzed by a final-year dental student under the supervision of an oral and maxillofacial radiology specialist.

To measure the dimensions of the airway in the anteroposterior direction, the following landmarks were used:

PNS: Posterior nasal spine

Go: Gonion, which is the hypothetical point of intersection of the tangent line to the descending ramus and the mandibular base.

B: The most posterior point in the bony curvature of the mandible between the lower incisor region and the chin

U: The tip of the uvula, which is the terminal part of the soft palate

MPW: The middle part of the pharyngeal wall, formed by connecting point U to the posterior wall of the pharynx

TPPW: The intersection point of the posterior wall of the pharynx and the continuation of the line connecting B to Go

TB: The intersection of the base of the tongue with the continuation of the line connecting B to Go

V: Vallecula, which is the most posterior-inferior point at the base of the tongue

LPW: The lower part of the pharyngeal wall, formed by connecting point V to the posterior wall of the pharynx

Based on the aforementioned landmarks, the dimensions of the airway were measured in each image as follows: The airway was evaluated at three points: superior, middle, and inferior in the sagittal view. In the superior section, the distance between U and MPW was measured; in the middle section, the distance between TB and TPPW was measured; and in the inferior section, the distance between V and LPW was measured as three parts of the airway.

Additionally, the vertical airway height (VAL) was measured as the distance from point V to PNS.

To evaluate the position and location of the hyoid bone in the anteroposterior direction, the following landmarks were used:

1. H point (Hyoid point): the most anterior-superior point on the body of the hyoid bone
2. R point (RGN point): the most posterior-inferior point in the mandibular symphysis
3. S point (Sella): the mid-point in the pituitary fossa

Based on the mentioned landmarks, the position and location of the hyoid bone were measured in each image as follows: The distance between point S and

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point H, as well as the distance between points H and RGN, were considered as two criteria for the position of the hyoid bone.

To evaluate the soft tissue profile in the anteroposterior direction, the following landmarks were used:

- **L1**: Incisal tip of the lower incisor
- **U1**: Incisal tip of the upper incisor
- **UL**: The most prominent point of the upper lip
- **LL**: The most prominent point of the lower lip
- **N**: The cross point of the nasal and frontal bone
- **Me**: The most inferior point of the mandibular symphysis in the midline
- **Pog**: The most prominent point of the chin bone

Based on the mentioned landmarks, the soft tissue profile was measured in each image as follows:

The size of the **E LINE**, which is a line drawn from the tip of the nose to Pog, was measured along with the distances of the upper and lower lips (UL and LL) to this line.

The angles **FCA**, **ILA**, **MLA**, **NLA**, and **HNB** were also measured:

- **HNB**: The angle between the intersection of NB and line H, which passes through the prominence of the upper lip and Pog.
- **NLA**: The angle between the lower lip and the prominence of Me.
- **ILA**: The angle between the upper and lower lips.
- **MLA**: The angle between the base of the nose and the upper lip.
- **FCA**: The facial convexity angle, formed by the intersection of points glabella, the base of the nose (subnasal), and Pog

Figure 1 and 2 are examples of the traced graphs of a patient before and after treatment, along with the mentioned measurements.

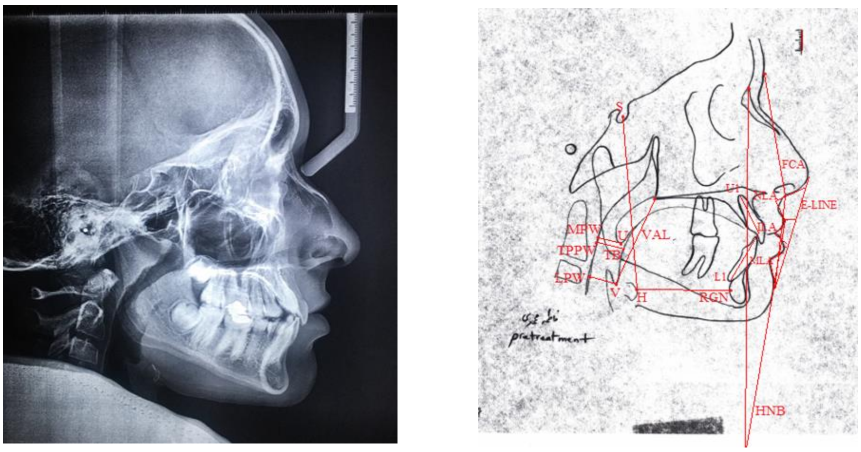

Figure 1. Radiography of the patient before treatment, along with its tracing and the mentioned measurements.

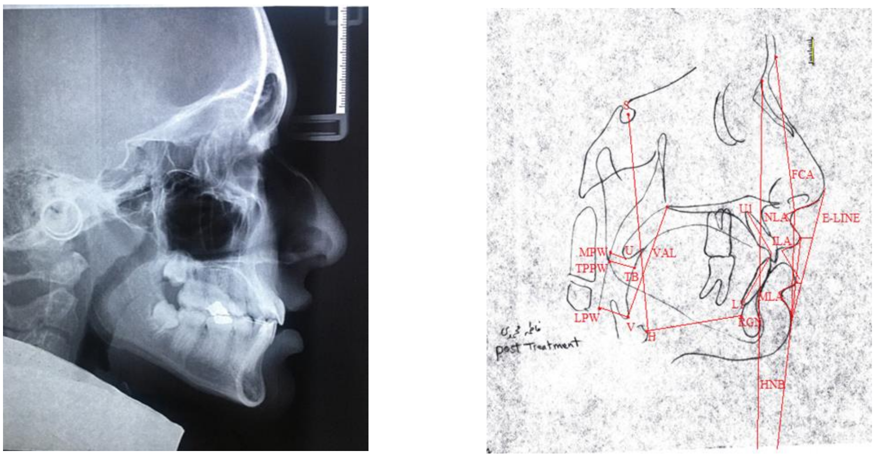

Figure 2. Radiography of the patient after treatment, along with its tracing and the mentioned measurements.

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The normality of the data was assessed using the Shapiro-Wilk test. Subsequently, the obtained data were analyzed using the paired t-test and Pearson correlation coefficient with SPSS software (version 24). A significance level of α = 0.05 was used for all statistical analyses.

Results

The results of the Paired t-test indicated that the means of the variables UL-E LINE (P = 0.001), LL-E LINE (P = 0.006), S-H (P = 0.038), and HNB (P = 0.049) showed a significant decrease after treatment compared to before treatment. However, no significant differences were observed in other soft tissue variables before and after treatment (P > 0.05) (Table 1).

Table 1. Comparison of mean values of soft tissue variables before and after treatment

Variable		N	Mean ± SD	P value
E LINE	before	27	62.96 ± 6.06	0.671
	after	27	62.38 ± 6.60	
UL-E LINE	before	27	-2.98 ± 2.88	0.001
	after	27	-4.14 ± 2.82	
LL-E LINE	before	27	0.2 ± 2.50	0.006
	after	27	-1.21 ±3.59	
H-RGN	before	27	35.2 ±4.91	0.112
	after	27	33.43 ±6.75	
S-H	before	27	97.45 ±10.84	0.038
	after	27	93.12 ±10.66	
1L-1U	before	27	116.77 ±9.46	0.277
	after	27	119.44 ±12.10	
FCA	before	27	161.13 ±6.37	0.074
	after	27	132.18 ±6.94	
NLA	before	27	94.15 ±9.11	0.861
	after	27	93.72 ±13.41	
ILA	before	27	91.35 ±11.06	0.918
	after	27	91.61 ±8.50	
MLA	before	27	111.55 ±15.61	0.229
	after	27	107.61 ±19.03	
HNB	before	27	15.74 ±3.20	0.049
	after	27	14.81 ±3.23	
VAL	before	27	56.04 ±8.28	0.150
	after	27	53.28 ±9.32	
U-MPW	before	27	9.8 ±2.20	0.318
	after	27	9.21 ±2.71	
TB-TPPW	before	27	11.87 ±2.88	0.146
	after	27	11.11 ±3.06	
LPW-V	before	27	13.14 ±3.44	0.861
	after	27	13 ±3.99	

The results of the Pearson correlation test showed no statistically significant correlation between U1-L1 and any of the airway, hyoid bone, and soft tissue profile variables either before or after treatment. However, a significant negative correlation was found between HNB and U1-L1 before treatment(P= 0.01, r = -0.486), and a significant positive correlation was observed between FCA and U1-L1 after treatment (P = 0.021, r = 0.441). These findings indicate that before treatment, as HNB increased, U1-L1 tended to decrease, and following the treatment, higher FCA values were associated with greater U1-L1 values (Table 2).

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Table 2. Correlation between U1-L1 and pharyngeal airway variables, hyoid bone, and soft tissue profile before and after treatment.

Variable	before treatment		after treatment	
	P value	R	P value	R
E LINE	0.280	-0.216	0.460	0.148
H-RGN	0.402	0.168	0.058	0.369
S-H	0.581	0.111	0.119	0.307
FCA	0.075	0.349	0.021	0.441
NLA	0.888	-0.028	0.114	0.311
ILA	0.178	-0.267	0.057	-0.371
MLA	0.832	0.043	0.795	-0.052
HNB	0.010	-0.486	0.194	-0.258
VAL	0.738	-0.068	0.887	0.029
U-MPW	0.956	-0.011	0.468	0.146
TB-TPPW	0.762	-0.061	0.796	0.052
LPW-V	0.882	0.03	0.393	-0.171

The results of the Pearson correlation test indicated that no significant correlations were found between the U1-E line and the airway variables, hyoid bone, and soft tissue profile variables before and after treatment. However, a strong positive correlation was observed between HNB and U1-E line before treatment (P = 0.0001, r = 0.714). After treatment, the U1-E line showed significant negative correlations with H-RGN (P = 0.003, r = -0.546), SH (P = 0.001, r = -0.598), FCA (P = 0.019, r = -0.45), and a significant positive correlation with HNB (P = 0.002, r = 0.56). These findings suggest that U1-E line may be associated with positional changes in the hyoid bone and certain cephalometric soft tissue parameters following orthodontic treatment (Table 3).

Table 3. Correlation between U1 e line and pharyngeal airway variables, hyoid bone, and soft tissue profile before and after treatment.

Variable	before treatment		after treatment	
	P value	R	P value	r
E LINE	0.466	0.146	0.602	-0.105
H-RGN	0.058	-0.37	0.003	-0.546
S-H	0.311	-0.202	0.001	-0.598
FCA	0.096	-0.327	0.019	-0.45
NLA	0.657	-0.09	0.337	-0.192
ILA	0.344	0.189	0.296	0.209
MLA	0.601	0.105	0.593	0.108
HNB	0.000	0.714	0.002	0.56
VAL	0.233	-0.237	0.238	-0.235
U-MPW	0.364	0.182	0.079	-0.344
TB-TPPW	0.441	0.155	0.142	-0.29
LPW-V	0.693	-0.08	0.255	-0.227

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The results of the Pearson correlation test indicated that no statistically significant correlations were found between L1-E line and most pharyngeal airway variables, hyoid bone, and soft tissue profile variables before and after treatment. However, a strong positive correlation was observed between HNB and L1-E line before treatment (P = 0.0001, r = 0.718). After treatment, L1-E line showed significant negative correlations with H-RGN (P = 0.011, r = -0.4816), SH (P = 0.006, r = -0.511), FCA (P = 0.004, r = -0.537), NLA (P = 0.020, r = -0.445), as well as a significant positive correlation with HNB (P = 0.003, r = 0.552). These findings indicate that changes in L1-E line may be associated with modifications in hyoid bone position and soft tissue profile following orthodontic treatment (Table 4).

Table 4. Correlation between L1 e line and pharyngeal airway variables, hyoid bone, and soft tissue profile before and after treatment.

Variable	before treatment		after treatment	
	P value	r	P value	r
E LINE	0.499	0.136	0.468	-0.146
H-RGN	0.317	-0.2	0.011	-0.481
S-H	0.127	-0.301	0.006	-0.511
FCA	0.065	-0.36	0.004	-0.537
NLA	0.988	0.003	0.020	-0.445
ILA	0.314	0.201	0.851	0.038
MLA	0.326	0.196	0.213	0.248
HNB	0.000	0.718	0.003	0.552
VAL	0.392	-0.172	0.722	-0.072
U-MPW	0.382	0.175	0.170	-0.272
TB-TPPW	0.486	0.14	0.25	-0.229
LPW-V	0.904	-0.024	0.89	0.028

Discussion

According to the results of the present study, no significant difference was observed in the airway before and after treatment. However, in the assessment of the hyoid bone position, the S-H distance significantly decreased, indicating a change in the position of this bone to a more superior location. Additionally, in the evaluations of the soft tissue profile, the distance from the upper and lower lips to the E-LINE decreased after treatment, suggesting a retraction of the lips during treatment. The H.NB angle also decreased after treatment, indicating a retraction of the lips along with a reduction in facial convexity. Statistical analysis showed a correlation between the angle of the incisors, which is a dental-alveolar variable, and the facial convexity angle (FCA) and the H.NB angle.

In previous studies, researchers have obtained various results regarding this issue. In a study performed by Maurya et al. (13), they stated that in both groups of patients treated with and without the extraction of premolars, no changes were observed in the airway and the position of the hyoid bone after treatment. The findings of this study concerning changes in the airway align with the results of the present study.

The results of the study by Al Maaitah et al. (14) indicated that although the extraction of premolars retracted the anterior teeth, it decreased the length of the tongue, the upper and lower jaws, but the dimensions of the upper airway did not change during

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treatment. The findings of this study were also consistent with the results of the present study.

Chopra et al. (12) utilized linear variables (HP-PNS, BP-PNS, SPW-SPPW, U-UPPW, PgT-PPTW, UPA, LPA) for the airway and variables (H-Pg, H-Hp, C3-H, PTM-H) for measuring the position of the hyoid bone in their study. They stated that the retraction of incisors in the space of extracted premolars led to a reduction in the airway in the oropharynx and hypopharynx, and the position of the hyoid bone shifted to a posterior-inferior location. This finding contradicts the results of the present study, and this difference may be attributed to variations in the measured variables as well as anatomical differences in the position of the hyoid bone.

Soheilifar et al. (15) studied borderline Class 1 patients divided into two groups: with and without the extraction of premolars, and concluded that in the second group, both the teeth and the lower lip moved forward. In contrast, in the group where premolars were extracted, both the lips and the teeth were retracted backward.

In a study by Freitas et al. (16), by examined lateral cephalograms before and after treatment, reporting that after treatment, the interlabial angle increased while the H.NB angle decreased. They attributed the decrease in the H.NB angle to potential mandibular growth during the growth phase, the retraction of the upper lip, and the anterior movement of the soft tissue pogonion. Additionally, the retraction of both lips indicated a reduction in facial profile prominence. The difference with the present study was that no change in the interlabial angle was observed, which may be due to anatomical variations and soft tissue changes during growth periods.

In the present study, although no significant differences were observed in the upper airway at the upper, middle, and lower points after the extraction of premolars, the S-H distance, which relates to the position of the hyoid bone, significantly decreased. This may indicate a change in the position of the hyoid bone to a more superior location. Additionally, in the soft tissue profile analyses, the distance from the upper and lower lips to the E-LINE decreased, indicating a retraction of the lips. The H.NB angle also significantly decreased, reflecting a reduction in facial profile convexity.

Based on a general conclusion, it can be stated that due to the contradictory results in studies regarding changes and reductions in the upper airway and the positional changes of the hyoid bone following premolar extractions, it is not possible to comment definitively on this matter. However, regarding soft tissue profile changes, it is highly likely that the retraction of the lips and the reduction in facial profile convexity are a result of premolar extractions. Therefore, when selecting Class I cases and planning treatment involving premolar extractions, careful consideration is essential, taking into account patient satisfaction and factors related to the profile before treatment.

Conclusion

Fixed orthodontic treatment involving the extraction of premolars in Class I patients showed no significant change in the upper airway, unlike the position of the hyoid bone. Additionally, both lips are retracted backward, and the convexity of the facial profile decreases.

Conflict of Interests:

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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