Adaptive Changes in the Posterior Pharyngeal Wall Following Large Retraction of Incisors During Comprehensive Orthodontic Treatment

Ashok Kumar Jena, Venkatachalapathy Anusuya, Jitendra Sharan

Department of Dentistry, All India Institute of Medical Sciences, Sijua, Bhubaneswar, Odisha, India

Main Points

- The retraction of incisors does not affect the sagittal dimensions of the upper airway.
- The sagittal thickness of the posterior pharyngeal wall decreases significantly as an adaptation to maintain the patency of the upper airway following the retraction of incisors.
- The adaptive changes in the posterior pharyngeal wall occur mainly at the retropalatal and retroglossal regions.
- The adaptive change in the posterior pharyngeal wall can be considered as a risk factor for future sleep-disordered breathing development.

ABSTRACT

Objective: To evaluate the effects of large retraction of incisors on the adaptive changes in the posterior pharyngeal wall and soft palate during comprehensive orthodontic treatment.

Methods: Twenty-seven females with Class I mild crowding or spacing who required non-extraction treatment (group I) and 34 females with Class I bimaxillary dentoalveolar protrusion who required all first premolars extraction for the retraction of their incisors (group II) were included in the study. The effects of non-extraction and incisor retraction following all first premolars extraction orthodontic treatment on the sagittal dimensions of pharyngeal airway passage and posterior pharyngeal wall thickness were evaluated from pre- and post-treatment cephalograms.

Results: The dimensions of pharyngeal airway passage were comparable among the groups. The length of the soft palate increased ($P < .01$) and the thickness of the soft palate decreased ($P < .01$) following retraction of incisors, and the difference between the groups was significant ($P < .05$). The posterior pharyngeal wall thickness was reduced significantly at PPWT2 ($P < .05$), PPWT3 ($P < .001$), PPWT4 ($P < .001$), PPWT5 ($P < .001$), and PPWT6 ($P < .01$) regions following retraction of the incisors, and the difference between the groups was statistically highly significant.

Conclusions: The large retraction of incisors during comprehensive orthodontic treatment in Class I bimaxillary dentoalveolar protrusion malocclusion subjects did not affect the sagittal dimensions of pharyngeal airway passage, but the thickness of the posterior pharyngeal wall reduced significantly as an adaptation to maintain the patency of the upper airway.

Keywords: Bimaxillary protrusion, incisor retraction, pharyngeal airway passage, upper airway, pharyngeal wall thickness, sleep-disordered breathing

INTRODUCTION

Extraction of all first premolars and retraction of incisors is a well-established treatment option for the management of Class I bimaxillary dentoalveolar protrusion malocclusions. The retraction of incisors leads to a reduction of oral volume and the available space for the accommodation of the tongue. This often leads to the posterior position of the tongue and reduction of pharyngeal airway passage (PAP) dimensions. Though this proposed mechanism is theoretically acceptable, the reduction of PAP dimensions following retraction of incisors is still...
controversial. There are many studies in the literature supporting the reduction of PAP dimensions and volume following retraction of incisors. However, a lot of studies also reported no changes in the PAP dimensions after the retraction of incisors. Although the evaluation of upper airway dimensions by using three-dimensional images is considered the best method, the results are conflicting. One study reported extraction orthodontic treatment leads to adaptive changes in the upper airway morphology. As the changes in the upper airway dimensions following extraction orthodontic treatment are confusing and controversial, there might be compensatory adaptations in the surrounding soft tissue. To the best of our knowledge, there is no study evaluating the adaptive changes in the surrounding soft tissue of the upper airway following maximum retraction of the incisors. Thus, the present study was designed to evaluate the effects of retraction of incisors on the sagittal thickness of the posterior pharyngeal wall among the subjects with Class I bimaxillary dentoalveolar protrusion malocclusions.

METHODS

This retrospective study was conducted in the Division of Orthodontics, Department of Dentistry, All India Institute of Medical Sciences, Bhubaneswar, India. Assuming the mean difference of 0.5 mm in the thickness of posterior pharyngeal wall at the level of oropharynx between the groups, 0.65 mm as standard deviation (SD), 95% Confidence Interval, 80% power, a sample size of 27 in each group was calculated. Open Epi version 3, an open source calculator was used for calculation of sample size. Orthodontic record files of 348 subjects who had completed comprehensive orthodontic treatment between January 2015 and December 2020 were reviewed by one of the authors (AKJ). Of 348, 78 (M = 17, F = 61) subjects met the selection criteria. The inclusion criteria were:

- Age between 18-25 years;
- Class I skeletal relationship;
- Similar vertical facial growth pattern (normodivergent growth; Frankfort mandibular plane angle (FMA), 25˚ ± 5˚);
- Female subjects having Class I malocclusion with mild crowding or spacing (≤4 mm) who were treated by non-extraction treatment;
- Female subjects having Class I bimaxillary dentoalveolar protrusion malocclusions with mild crowding or spacing (≤4 mm) who were treated by all first premolars extraction and had a minimum of 5 mm retraction of maxillary and mandibular incisors; and
- Good quality pre- and post-treatment lateral cephalograms with hard and soft tissue details.

Subjects with a history of comprehensive orthodontic treatment, surgery for pharyngeal pathology and nasal obstruction, snoring, and any systemic disease were excluded.

Of 78 selected subjects, there were only 17 males. Thus, all female subjects (n = 61) were included in the study. Of 61 subjects, 27 subjects who had Class I dental malocclusions with mild crowding or spacing (≤4 mm) on Class I skeletal relationship and treated by non-extraction orthodontic treatment were included in Group I. Group II included the rest of the 34 subjects who had Class I bimaxillary dentoalveolar protrusion malocclusions with mild crowding or spacing (≤4 mm) on Class I skeletal relationship and treated by all first premolars extraction for the retraction of their anterior teeth. Written informed consent had been obtained from each patient for the comprehensive orthodontic treatment and to use their records for various academic and research activities. The present study was approved by the Institute Ethics Committee (T/IM-NF/Dentistry/20/151) and was conducted according to the principles of the Helsinki Declaration.

All the subjects selected for the study had been treated by the same operator (AKJ). The malocclusion in all subjects was corrected by a standard edgewise appliance system (0.018” slot, American Orthodontics, Sheboygan, WI, USA). In Group II subjects, anchorage in the maxillary and mandibular arches was reinforced by the Nance button and lingual arch, respectively, and 2 steps space closure technique was followed. In all subjects, the cephalograms were recorded before the beginning and 1 week after the completion of comprehensive orthodontic treatment. All cephalograms were recorded with the same machine (NewTom GiANO, Imola, Bolanga, Italy) with the same exposure parameters (80 Kvp, 10 mAs, and 1.6 seconds). While recording the lateral cephalograms, subjects were placed in the standing position with Frankfort horizontal plane parallel to the floor and teeth in centric occlusion. The heads of the subjects were kept erect. The cephalograms were exposed at the end-expiration phase of the respiration. Subjects were instructed not to move their heads and tongues and not to

![Figure 1. Cephalometric landmarks, reference planes, and linear and angular parameters used for the evaluation of sagittal and vertical jaw relationships and the amount of incisor retraction](image-url)
swallow during the exposure of cephalograms. All the lateral cephalograms were traced manually by the same evaluator (AKJ).

The method for the evaluation of sagittal and vertical jaw relationships and the amount of maxillary and mandibular incisors retraction are shown in Figure 1. The landmarks were sella (S), nasion (N), porion (Po), orbitale (Or), gonion (Go), Point A (A), Point B (B), menton (Me), pterygomaxillary fissure (Ptm), the tip of upper incisor (U1), and the tip of the lower incisor (L1). The reference planes included SN plane, the line joining S and N; FH plane, the line joining Po and Or; Ptm perpendicular, the perpendicular plane on FH plane at Ptm; S perpendicular, perpendicular plane on FH plane at S; and mandibular plane, the line joining Go and Me. The linear parameters included (1) U1 to Ptm perpendicular, the perpendicular distance from U1 to Ptm perpendicular; (2) U1 to S perpendicular, the perpendicular distance from U1 to S perpendicular; (3) L1 to Ptm perpendicular, the perpendicular distance from L1 to Ptm perpendicular; (4) L1 to S perpendicular, the perpendicular distance from L1 to S perpendicular. The angular parameters considered were (5) SNA, the angle between S, N, and A; (6) SNB, the angle between S, N, and B; (7) ANB, the angle between A, N, and B; (8) FMA, the angle between the FH plane and the mandibular plane.

The sagittal dimensions of PAP were determined according to the method described in previous studies and mentioned in Figure 2. The cephalometric landmarks included N, Po, Or, posterior nasal spine (PNS), Ptm, basion (Ba); the tip of soft palate (U), upper pharyngeal wall (UPW), the intersection of line Ptm-Ba and posterior pharyngeal wall; middle pharyngeal wall (MPW), the intersection of perpendicular on Ptm perpendicular from U with the posterior pharyngeal wall, vallecula (V), and lower pharyngeal wall (LPW), the intersection of perpendicular on Ptm perpendicular from V with the posterior pharyngeal wall. The FH plane, Ptm perpendicular, and Ba-N plane, the line joining Ba and N were considered as reference planes. Various linear parameters included (1) DNP (Ptm-UPW); (2) HNP, the shortest linear distance from PNS to Ba-N plane; (3) DOP (U-MPW); (4) DHP (V-LPW); (5) soft palate length (SPL) (U-PNS); (6) soft palate thickness (SPT), the maximum thickness of the soft palate. The angular parameter included (7) soft palate inclination (SPI) (Ptm perpendicular × PNS-U), the angle between Ptm perpendicular and the soft palate (PNS-U).

The posterior pharyngeal wall thickness (PPWT) was evaluated according to the method mentioned by Ghodke et al. and Joseph et al. (Figure 3). Various landmarks were anterior nasal spine (ANS), PNS, mid-point of soft palate (MSP; it is the intersection of PNS-U line and a line representing the maximum thickness of soft palate); U, Go, Me, superior-anterior point of C3 vertebra (SC3); inferior-anterior point of C3 vertebra (IC3). Reference planes were (1a) palatal plane (ANS-PNS), (2b) mandibular plane, (3c) anterior tangent to C2 vertebra, a tangent is drawn along the anterior border of C2 vertebra; (4d) the long axis of the soft palate (PNS-U). The linear parameters included (1) PPWT1, the distance from the intersection point of palatal plane and posterior pharyngeal wall to the intersection point of palatal plane and anterior tangent of C2 vertebra; (2) PPWT2, the distance from the intersection point of the line parallel to
the palatal plane passing through U and the posterior pharyngeal wall to the intersection point of the same line extended posteriorly and anterior tangent of C2 vertebra; (3) PPWT3, the distance from the intersection point of the line parallel to the palatal plane passing through U and the posterior pharyngeal wall to the intersection point of the same line extended posteriorly and anterior tangent of C2 vertebra; (4) PPWT4, the distance from the intersection point of the mandibular plane and posterior pharyngeal wall to the intersection point of the mandibular plane and anterior tangent of C2 cervical vertebra; (5) PPWT5, the distance from the intersection point of the line parallel to the mandibular plane passing through the superior-anterior point of C3 vertebra and the posterior pharyngeal wall to superior-anterior point of C3 vertebra; (6) PPWT6, the distance from the intersection point of the line parallel to mandibular plane passing through the inferior-anterior point of C3 vertebra and the posterior pharyngeal wall to inferior-anterior point of C3 cervical vertebra.

The linear magnifications of radiographs were corrected and calibrated according to the magnification factor, using the radiopaque ruler (calibration marker). The linear parameters were measured by digital caliper to the nearest 0.01 mm and protractor to the nearest 0.5° degree for the measurement of angular measurements. All the parameters were measured twice and their mean was considered for the statistical analysis. The assessment of intra-observer error and reproducibility of landmark location and measurement errors was analyzed by retracing the 10 randomly selected cephalograms after a gap of 15 days. The intra-observer reliability of the measurements was calculated by the intraclass correlation coefficient (ICC) for the measurements obtained by the evaluator at both times.

**Statistical Analysis**

All the statistical analyses were performed in the Statistical Package for the Social Sciences software (for Windows 7, version 25, SPSS, Chicago, Ill, USA). Descriptive statistics were used. Shapiro–Wilk’s test was used to examine the normality of the data. The significant changes between pre- and post-treatment values in each group were determined by paired t-test. Any significant difference in the changes between the 2 groups was evaluated by an unpaired t-test. The P value of .05 was considered as the level of significance.

**RESULTS**

The ICC ranged from 0.96 to 0.99 showing excellent reliability between the measurements. The mean age of the subjects at the beginning of treatment was 21.04 ± 2.08 years and 22.50 ± 3.53 years in Group I and II subjects, respectively (P = .922). The mean duration of treatment was 405.96 ± 124.32 days in Group I and 794.5 ± 105.35 days in Group II subjects (P < .001). The mean body mass index (BMI) of the subjects among Group I and II subjects at the beginning was 21.04 ± 2.08 years and 22.50 ± 2.51 years in Group I and II subjects, respectively (P = .100). The mean BMI of the subjects among Group I and II subjects at the beginning (P = .638) and end of the treatment (P = .846) was comparable. Various parameters for the sagittal and vertical skeletal jaw relationships and the mean retraction of the maxillary and mandibular incisors are mentioned in Table 1. The mean change of SNA, SNB, ANB, and FMA was very minimum during the treatment in each group and the mean differences were statistically comparable. The mean forward or backward movement of upper and lower incisors during the treatment was very minimum in Group I subjects. In Group II subjects, the mean retraction of the upper and lower incisors in relation to the Ptm perpendicular was 6.39 ± 1.18 mm and 5.77 ± 1.26 mm, respectively, and in relation to the Sella (S) perpendicular, it was 6.69 ± 1.67 mm and 6.24 ± 1.47 mm, respectively.

The sagittal PAP dimension changes are described in Table 1. In Group I subjects, non-extraction orthodontic treatment had no significant effect on sagittal PAP dimensions and soft palate. In Group II subjects, incisor retraction did not affect sagittal PAP dimensions, but it had a significant effect on the length (P < .01), thickness (P < .01), and inclination (P < .05) of the soft palate. The SPL increased from 31.67 ± 4.07 mm to 32.64 ± 3.73 mm following the retraction of incisors (P = .003). The SPT decreased from 8.60 ± 1.41 mm to 7.66 ± 1.28 mm (P = .001) and the SPI from 41.76° ± 6.10° to 43.26° ± 5.60° (P = .041) by the retraction of incisors in Group II subjects. Between the groups, the comparison showed a significant difference in the changes of SPL and SPT (P < .05).

The changes in the sagittal thickness of the posterior pharyngeal wall are described in Table 1. In Group I, non-extraction orthodontic treatment had no significant effect on the sagittal PPWT except PPWT4 (P < .05), which decreased from 3.07 ± 0.90 mm to 2.51 ± 0.64 mm following the treatment. But in Group II subjects, all the variables related to the measurement of the sagittal thickness of the posterior pharyngeal wall were decreased significantly following the retraction of the incisors except PPWT1. The inter-group comparison showed a statistically significant difference for PPWT2 (P < .05), PPWT3 (P < .001), PPWT4 (P < .01), and PPWT5 (P < .001) changes.

**DISCUSSION**

There are many diagnostic aids for the evaluation of PAP dimensions and sagittal thickness of the posterior pharyngeal wall. However, lateral cephalograms are the most commonly used one. Miles et al. reported high reliability of cephalometric landmarks and measurements for the same. The commonly used cephalometric landmarks for the evaluation of airway structures can also be reliably identified. Thus, cephalograms are still used widely to evaluate the sagittal dimensions of the upper airway. The American Association of Orthodontists’ white paper on obstructive sleep apnea and orthodontics suggested that 3D evaluation of the upper airway is ideal for the evaluation of upper airway dimensions. However, the primary outcome measure in the present study was to evaluate the sagittal thickness of the posterior pharyngeal wall which is a 2D variable, so lateral cephalograms were considered as an appropriate tool for the same outcome measure.
Table 1. Comparison of skeletal, dental, pharyngeal variables at pre- and post-treatment within groups and comparison of treatment changes between groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-Treatment Mean ± SD</th>
<th>Post-Treatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>Significance (P Value)</th>
<th>Pre-Treatment Mean ± SD</th>
<th>Post-Treatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>Significance (P Value)</th>
<th>Comparison of Mean Differences Gr. I vs. Gr. II Significance (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA (°)</td>
<td>82.26 ± 2.04</td>
<td>82.48 ± 1.96</td>
<td>0.22 ± 1.01</td>
<td>0.265 **</td>
<td>82.18 ± 1.89</td>
<td>82.26 ± 2.46</td>
<td>0.08 ± 1.35</td>
<td>.707 NS</td>
<td>0.248 NS</td>
</tr>
<tr>
<td>SNB (°)</td>
<td>80.22 ± 2.92</td>
<td>80.56 ± 2.24</td>
<td>0.33 ± 1.41</td>
<td>0.232 **</td>
<td>79.59 ± 2.42</td>
<td>80.18 ± 2.71</td>
<td>0.58 ± 1.25</td>
<td>.010 *</td>
<td>0.460 NS</td>
</tr>
<tr>
<td>ANB (°)</td>
<td>2.00 ± 1.00</td>
<td>1.93 ± 1.26</td>
<td>−0.07 ± 1.10</td>
<td>0.731 NS</td>
<td>2.59 ± 1.25</td>
<td>2.09 ± 1.21</td>
<td>−0.50 ± 1.05</td>
<td>.009 **</td>
<td>0.130 NS</td>
</tr>
<tr>
<td>FMA (°)</td>
<td>22.30 ± 1.79</td>
<td>22.48 ± 1.84</td>
<td>0.18 ± 0.96</td>
<td>0.327 NS</td>
<td>25.41 ± 2.06</td>
<td>25.15 ± 2.06</td>
<td>−0.26 ± 1.37</td>
<td>.271 NS</td>
<td>0.155 NS</td>
</tr>
<tr>
<td>U1-Ptm perpendicular (mm)</td>
<td>54.80 ± 4.24</td>
<td>54.47 ± 4.03</td>
<td>−0.33 ± 2.31</td>
<td>0.465 NS</td>
<td>57.49 ± 3.69</td>
<td>51.10 ± 3.34</td>
<td>−6.39 ± 1.18</td>
<td>.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>L1-Ptm perpendicular (mm)</td>
<td>73.21 ± 4.38</td>
<td>72.52 ± 4.12</td>
<td>−0.69 ± 2.78</td>
<td>0.206 NS</td>
<td>74.35 ± 5.37</td>
<td>67.65 ± 5.13</td>
<td>−6.69 ± 1.67</td>
<td>.009 **</td>
<td>0.000**</td>
</tr>
<tr>
<td>L1-S perpendicular (mm)</td>
<td>50.70 ± 4.29</td>
<td>51.03 ± 3.94</td>
<td>0.23 ± 3.22</td>
<td>0.604 NS</td>
<td>53.41 ± 4.06</td>
<td>47.64 ± 3.83</td>
<td>−5.77 ± 1.26</td>
<td>.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>DNP (mm) (Ptm-UPW)</td>
<td>69.30 ± 4.36</td>
<td>69.75 ± 3.81</td>
<td>0.45 ± 2.46</td>
<td>0.347 NS</td>
<td>70.65 ± 5.38</td>
<td>64.41 ± 5.05</td>
<td>−6.24 ± 1.47</td>
<td>.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>HNP (mm) (PNS to Ba-N plane)</td>
<td>21.28 ± 3.09</td>
<td>20.37 ± 3.24</td>
<td>−0.91 ± 2.42</td>
<td>0.062 GS</td>
<td>19.35 ± 4.58</td>
<td>18.91 ± 5.32</td>
<td>−0.44 ± 2.43</td>
<td>.290 NS</td>
<td>0.034*</td>
</tr>
<tr>
<td>DOP (mm) (U-MPW)</td>
<td>21.57 ± 2.24</td>
<td>21.85 ± 2.09</td>
<td>0.28 ± 0.82</td>
<td>0.099 GS</td>
<td>22.13 ± 2.49</td>
<td>21.82 ± 2.32</td>
<td>−0.31 ± 1.47</td>
<td>.229 GS</td>
<td>0.068 GS</td>
</tr>
<tr>
<td>DOP (mm) (U-MPW)</td>
<td>10.23 ± 2.90</td>
<td>10.20 ± 2.69</td>
<td>−0.03 ± 1.14</td>
<td>0.889 GS</td>
<td>10.50 ± 3.48</td>
<td>10.27 ± 3.39</td>
<td>−0.23 ± 2.04</td>
<td>.514 GS</td>
<td>0.650 NS</td>
</tr>
<tr>
<td>DHP (mm) (V-LPW)</td>
<td>14.77 ± 2.50</td>
<td>14.94 ± 2.29</td>
<td>0.16 ± 1.70</td>
<td>0.624 GS</td>
<td>14.72 ± 2.65</td>
<td>14.33 ± 2.23</td>
<td>−0.39 ± 1.65</td>
<td>.179 GS</td>
<td>0.206 GS</td>
</tr>
<tr>
<td>SPL (mm) (U-PNS)</td>
<td>30.96 ± 3.69</td>
<td>30.87 ± 3.28</td>
<td>−0.08 ± 2.22</td>
<td>0.821 GS</td>
<td>31.67 ± 4.07</td>
<td>32.64 ± 3.73</td>
<td>0.96 ± 1.50</td>
<td>.003**</td>
<td>0.040*</td>
</tr>
<tr>
<td>SPT (mm) (Maximum thickness of the soft palate)</td>
<td>8.80 ± 1.07</td>
<td>8.61 ± 1.23</td>
<td>−0.18 ± 0.86</td>
<td>0.270 GS</td>
<td>8.60 ± 1.41</td>
<td>7.66 ± 1.28</td>
<td>−0.94 ± 1.50</td>
<td>.001**</td>
<td>0.024*</td>
</tr>
<tr>
<td>SPI (°) (Ptm per x PNS-U)</td>
<td>38.41 ± 4.34</td>
<td>38.41 ± 5.64</td>
<td>0.00 ± 3.85</td>
<td>1.000 NS</td>
<td>41.76 ± 6.10</td>
<td>43.26 ± 5.60</td>
<td>1.5 ± 4.11</td>
<td>.041*</td>
<td>.151 NS</td>
</tr>
<tr>
<td>PPWT1 (mm)</td>
<td>16.16 ± 2.47</td>
<td>16.47 ± 2.41</td>
<td>0.30 ± 2.16</td>
<td>0.468 GS</td>
<td>16.56 ± 2.17</td>
<td>16.28 ± 2.20</td>
<td>−0.28 ± 2.19</td>
<td>.459 GS</td>
<td>0.300 GS</td>
</tr>
<tr>
<td>PPWT2 (mm)</td>
<td>8.12 ± 0.96</td>
<td>8.06 ± 1.05</td>
<td>−0.06 ± 0.83</td>
<td>0.699 GS</td>
<td>9.38 ± 2.33</td>
<td>8.44 ± 1.58</td>
<td>−0.94 ± 2.10</td>
<td>.013*</td>
<td>.044*</td>
</tr>
<tr>
<td>PPWT3 (mm)</td>
<td>4.12 ± 0.77</td>
<td>3.88 ± 0.77</td>
<td>−0.23 ± 0.66</td>
<td>0.084 GS</td>
<td>5.23 ± 0.88</td>
<td>3.99 ± 0.91</td>
<td>−1.24 ± 1.14</td>
<td>.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>PPWT4 (mm)</td>
<td>3.07 ± 0.90</td>
<td>2.51 ± 0.64</td>
<td>−0.56 ± 1.30</td>
<td>0.033*</td>
<td>4.25 ± 1.27</td>
<td>2.73 ± 0.95</td>
<td>−1.51 ± 1.36</td>
<td>.000***</td>
<td>0.008*</td>
</tr>
<tr>
<td>PPWT5 (mm)</td>
<td>3.80 ± 0.54</td>
<td>3.92 ± 0.50</td>
<td>0.12 ± 0.55</td>
<td>0.265 GS</td>
<td>4.71 ± 0.70</td>
<td>3.73 ± 0.52</td>
<td>−0.98 ± 0.70</td>
<td>.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>PPWT6 (mm)</td>
<td>3.76 ± 0.70</td>
<td>3.58 ± 0.57</td>
<td>−0.18 ± 0.74</td>
<td>0.204 GS</td>
<td>4.31 ± 0.65</td>
<td>3.89 ± 0.45</td>
<td>−0.42 ± 0.64</td>
<td>.001**</td>
<td>.188 NS</td>
</tr>
</tbody>
</table>
The effects of incisor retraction following all first premolars extraction among Class I bimaxillary dentoalveolar protrusion malocclusion subjects on PAP is controversial. Few studies reported a decrease in sagittal PAP dimensions following incisor retraction in Class I bimaxillary dentoalveolar protrusion malocclusion subjects. The retraction of the anterior teeth resulted in the dorsal movement of the anterior boundary of the oral cavity and enforced the tongue backward, resulting in the upper airway diminishing in size, especially in the base of the tongue and next in the back of the soft palate. However, the present study did not find any change in the sagittal PAP dimensions following retraction of incisors, and the changes were also comparable to non-extraction treatment subjects. Similar to the observations of the present study, many previous studies also reported no effect of incisor retraction on the sagittal PAP dimensions among adolescents and in adults. The growth of bone and soft tissue surrounding the upper airway and regression of the lymphoid tissue among adolescents probably mask the changes in the pharynx by the incisors’ retraction. A greater rate of changes in the soft-tissue measurements of the posterior pharyngeal wall occurs between 6 and 9 years and between 12 and 15 years. Thus, all the subjects above 18 years were included in the present study to ensure that the oropharyngeal structures had reached the adult size and the effect from growth would not affect the result. Also, many previous studies reported no effect of incisors retraction on the sagittal dimensions of PAP in adult subjects with Class I bimaxillary dentoalveolar protrusion malocclusions. Zhang et al. observed that extraction orthodontic treatment did not affect the sagittal and transverse dimensions, minimal cross-sectional area, and volume in the nasopharyngeal, retropalatal, or retroglossal regions of the upper airway in adult patients. Thus, the surrounding soft tissues might have some adaptive changes for maintaining the upper airway dimensions after incisors retraction among adult subjects. Marşan et al. observed that a more backward position of the tongue following large incisor retraction probably influences the soft palate and posterior pharyngeal walls to have adaptive changes. Previously, Zhang et al. have also observed that the effect of extraction treatment on the upper airway seems to be an adaptive change in the airway morphology, rather than a decrease in the airway size.

The current study revealed that there are no changes in the soft palate dimensions in non-extraction subjects. But the length and thickness of the soft palate were increased and decreased, respectively, following retraction of incisors. The retraction of incisors might push the tongue backward and compressed the soft palate, thus resulting in a decrease in its thickness and an increase in its length. Further, no effect of non-extraction orthodontic treatment on the PPWT was observed, whereas it decreased significantly following incisor re retractions among Class I bimaxillary malocclusions subjects. This could be an adaptive change in the posterior pharyngeal wall to maintain the sufficient patency of the upper airway. The loss of fat from the posterior pharyngeal wall might result in the reduction in its thickness. It was observed that the reduction of the PPWT was maximum at retropalatal and retroglossal regions compared to other regions. Such an adaptive change in the posterior pharyngeal wall may be a risk factor for the future development of sleep-disordered breathing, particularly when an individual becomes obese. The excess deposition of fat in the pharyngeal wall during adulthood can lead to constriction of the upper airway passage leading to the development of sleep-disordered breathing.

A systematic review reveals that bicuspid extraction and incisor retraction leads to narrowing of the upper airway in Asian adults and late adolescents. Although the present study did not find any significant narrowing of the upper airway, it revealed that significant adaptations of the soft tissues surrounding the upper airway take place following bicuspid extraction and incisor retraction in Class I bimaxillary dentoalveolar protrusion malocclusion subjects. Also, this was a retrospective cross-sectional study based on lateral cephalograms, which cannot tell about the patient’s subjective symptoms related to the breathing, casualty of orthodontic treatment, and 3D airway changes. However, the significance of this is to present clues of the PPWT changes following the retraction of the incisors during comprehensive orthodontic treatment. The present study included only female subjects, thus further investigations on males are needed to confirm the above conclusions and also longitudinal evaluations are needed to identify the long-term changes in the posterior pharyngeal wall following large retraction of the incisors.

The retraction of the incisors can be a risk factor for the future development of sleep-disordered breathing. Thus, before deciding about premolars extraction and large retraction of incisors, patients sleeping and breathing, and the family tendency for sleep-disordered breathing may be evaluated.

CONCLUSION

The following conclusions were drawn from the present study:

- The retraction of incisors in Class I bimaxillary dentoalveolar protrusion malocclusion subjects did not affect the sagittal dimensions of the pharyngeal airway passage.
- The thickness of the soft palate and posterior pharyngeal wall reduced as an adaptive change following the retraction of the incisors in Class I bimaxillary dentoalveolar protrusion malocclusion subjects.
- The adaptive change in the posterior pharyngeal wall was mainly at the retropalatal and retroglossal regions compared to other regions.

Ethics Committee Approval: This study was approved by the Institute Ethics Committee, All India Institute of Medical Sciences, Bhubaneswar (T/IM-NF/Dentistry/20/151) and was conducted according to the principles of the Helsinki Declaration.
Informed Consent: Written informed consent was obtained from each patient for the comprehensive orthodontic treatment and to use their records for various academic and research activities.

Peer-review: Externally peer-reviewed.


Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. Al Maaitah E, El Said N, Abu Alhaija ES. First premolar extraction effects on upper airway dimension in bimaxillary proclination patients. Angle Orthod. 2012;82(3):853-859. [CrossRef]
17. Jena AK, Singh SP, Utreja AK. Effectiveness of twin-block and mandibular protraction appliance-IV in the improvement of pharyngeal airway passage dimensions in Class II malocclusion subjects with a retrognathic mandible. Angle Orthod. 2013;83(4):728-734. [CrossRef]
25. Aldosari MA, Alqasir AM, Alqahtani ND, Almosa NA, Almoammar KA, Albarakati SF. Evaluation of the airway space changes after extraction of four second premolars and orthodontic space closure in adult female patients with bimaxillary protrusion - a retrospective study. Saud J Dent J. 2020;32(3):142-147. [CrossRef]