Lower Facial Height and Soft Tissue Changes in Bimaxillary Protrusion Cases

Kasmawarin1, Nurhayati Harahap2, Amalia Oeripto2
1 Postgraduate Program in Orthodontics, Faculty of Dentistry, University of North Sumatera – Indonesia
2 Department of Orthodontics, Faculty of Dentistry, University of North Sumatera – Indonesia

*Corresponding Author: Kasmawarin, Faculty of Dentistry, University of North Sumatera – Indonesia
Email: kas_ma85@yahoo.com

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ABSTRACT

Background: Bimaxillary protrusion is frequently treated by extracting the four first premolars and retracting the incisor with maximum anchorage. This treatment may result in soft tissue changes, particularly in lip retraction, lip thickness, upper lip angle and nasolabial angle. However, the changes in facial height after orthodontic treatment often trigger controversies. Objectives: To determine the effects of incisor retraction on lower facial height and soft tissue changes in Class I malocclusion with bimaxillary protrusion treated by the extraction of the four first premolars. Methods: Pretreatment and post-treatment lateral cephalometric radiograph samples of 25 patients treated with the standard Edgewise fixed appliance were collected. Each sample was traced and a reference line perpendicular to Sella-Nasion minus 7º through the true vertical line (TVL) was established. Arnett analysis was applied to calculate incisor retraction, lower facial height, lip retraction, lip thickness, upper lip angle and nasolabial angle changes. The results of the measurements were statistically analyzed using a paired T-test and Pearson correlation. Results: No statistically significant changes were found between upper incisor retraction and lower facial height ($p > 0.05$) and upper lip thickness ($p > 0.05$). The same lower incisor retraction occurred with lower facial height ($p > 0.05$) and lower lip thickness ($p > 0.05$). Significant positive correlation was found between upper incisor retraction and the changes in the upper lip retraction ($r = 0.959, p < 0.05$), upper lip angle ($r = 0.775, p < 0.05$) and nasolabial angle ($r = 0.647, p < 0.05$), while the lower incisor retraction had a positive correlation with the changes in lower lip retraction ($r = 0.902, p < 0.05$). Conclusion: The extraction of the four first premolars followed by the retraction of the incisor can cause changes in lip retraction, upper lip angle and nasolabial angle but not in lower facial height and lip thickness.

Keywords: bimaxillary protrusion, incisor retraction, lower facial height, soft tissue changes
Background

Orthodontic treatment aims to resolve dentoskeletal problems and to achieve the ideal occlusion, functional stability and facial and dental aesthetic harmony. Individuals often complain about unpleasant facial aesthetics and search for orthodontic treatment that is intended to restore balance to the facial profile, especially in protrusion cases. Bimaxillary protrusion, or bimaxillary dentoalveolar protrusion, is defined as the proclination and protrusion of maxillary and mandibular anterior teeth with molar teeth in a Class I Angle relationship. Usually, this is indicated by an increase in the procumbency of the lips and a convex facial profile, where the upper and lower lips are incompetent. Consequently, patients complain about the unpleasant aesthetic.

Orthodontic treatment in bimaxillary protrusion cases includes retraction and retroclination of maxillary and mandibular teeth, which have an impact on the reduction of procumbency and convexity of the soft tissue. This can be achieved through the extraction of the first four premolar teeth and followed by retraction of the anterior teeth using a maximum anchorage mechanism. The effect of premolar teeth extraction to vertical facial height continues to be debated. With the extraction, facial sagittal and vertical dimensions change with the movement of the molar teeth. Several researchers have stated that the coverage of molar teeth with a movement to mesial by extraction leads to the reduction of vertical dimensions and mandibular angle. In contrast, a number of researchers do not agree that teeth extraction leads to counterclockwise mandibular rotation and a decrease in facial vertical dimensions.

Moreover, the success of orthodontic treatment in bimaxillary protrusion cases that involve the extraction of the first four premolar teeth followed by incisor retraction causes changes in the soft tissue profile that are beneficial, such as the movement of the posterior of the upper and lower lips to reduce lip procumbency and the increase of nasolabial and mentolabial angle. Sukhia reported that there were changes in the soft tissue profile and a reduction in lower facial height with the extraction of the first four premolar teeth and the retraction of the incisor in bimaxillary protrusion cases.

Cephalometric radiography is one of the ways to measure facial aesthetics in orthodontics. With this radiography, many analyses can be used to evaluate lip position and soft tissue aesthetics, such as “E” (Ricketts), “S” (Steiner) and “H” (Holdaway) lines, “Z” (Merrifield Angle) and the True Vertical Line (TVL) by Arnett. The analysis put forward by Rickett, Steiner, Merrifield and Holdaway measure only the anteroposterior position from the furthest forward points of the upper and lower lips to the reference lines.

Along with the development in the orthodontic field, Arnett proposed an analysis to measure facial balance as well as diagnosis and treatment plans by combining clinical analysis for clinical facial analysis and hard tissue and soft tissue cephalometric analysis (STCA). One of the measurements for STCA is the TVL, which measures the distance between anteroposterior soft tissue and the dentoskeletal structure, which is combined with the thickness of the soft tissue.

STCA is an analysis for facial soft tissue cephalometry that can be used to diagnose five different facial areas that are related. Those areas include the dentoskeletal structure, soft tissue structure, facial height, TVL projection and facial harmony. An STCA value was obtained from a cephalogram acquired with the patient’s head in the natural position and with lips in a passive state.

This study aimed to determine the effects of incisor retraction on lower facial height and soft tissue changes in Class I malocclusion with bimaxillary protrusion using TVL-STCA by Arnett at the Orthodontic Specialists Clinic, University of Sumatera Utara.

Materials and Methods

This retrospective study incorporated 25 samples (based on a minimum sample size calculation) of medical records and lateral cephalometric radiographs of male and female patients between 18 and 35 years of age with malocclusion class I (ANB: 2° ± 2°) with bimaxillary protrusion (maxillary incisor proclination ı:SN > 102° ± 2° and mandibular incisor proclination ı:MP > 90° ± 3°). The
patients were treated with extraction of four premolar teeth and orthodontic treatment using standard Edgewise 0.018-in. brackets. All samples were collected randomly by an operator at the Orthodontic Specialists Clinic, University of North Sumatera.

The cephalometric radiographs consist of pre- and post-treatment. Each cephalometric radiograph was traced and had reference lines drawn by dragging lines that connect S (Sella) points with Na (Nasion) points. Then x-axis was determined through the S-NA line by forming a 7° angle downwards through the S point (SN minus 7°), while the y-axis, which is the TVL, was determined through the subnasale and perpendicular to the x-axis. The changes in incisor retraction was measured from the TVL projection from the Mx1 and Md1 points. There are the distances measured from the TVL to the incisal edge of the maxillary and mandibular incisor, respectively. The measurement for lower facial height is the space between the soft tissue of the subnasale and the menton (Fig. 1).

The changes in soft tissue were measured by the projection of the TVL and soft tissue structure. Each TVL projection against ULA (upper lip anterior) and LLA (lower lip anterior) was used to determine the extent of the change in the upper and lower lips anteroposterior (Fig. 1). The soft tissue structure includes upper lip thickness (the distance from ULA to upper lip inside), lower lip thickness (the distance from lower lip outside to the inside), upper lip angle (the angle formed from ULA and TVL that passes the Sn point) and nasolabial angle (the angle formed from nose base and ULA passing the Sn point). The soft tissue structure is shown in Fig. 2.

The measuring was done twice by an operator, and an intra-rater reliability test was performed. Further, a Shapiro-Wilk test was conducted to see the normality of measurement. Pre- and post-treatment variables were analyzed using a T-paired test. To see the correlation between incisor retraction and lower facial height and soft tissue, a Pearson correlation was used.

![Figure 1. Reference lines and points used in this study.](image1)

![Figure 2. Soft tissue structure.](image2)
Result

This study was conducted at the Orthodontic Specialists Clinic, University of Sumatera Utara, with 25 cephalometry radiographs of patients between 18 and 35 years of age (26.08 ± 4.67) with malocclusion Class I (ANB: 2.46° ± 1.16°) with bimaxillary protrusion (maxillary incisor proclination LS:N 116.2° ± 4.56° and mandibular incisor proclination MP: 105.14° ± 5.65°). Of the patients, 32% were male and 68% were female, and they were treated with four premolar teeth extraction and orthodontic treatment using standard Edgewise 0.018-in. brackets.

Samples measurements were done twice by an operator. A consistency test using intra-rater reliability shows that the first and second data are reliable or consistent with Cronbach’s Alpha value of > 0.398. Thus, data taken was from one of the measurements. The Shapiro-Wilk normality tests shows that data was distributed normally (p > 0.05).

The amount of maxillary and mandibular incisor retraction and changes to the lower facial height and facial soft tissue pre- and post-treatment are shown in Table 1. Change is considered significant in all variables with a p value of < 0.05. Table 2 shows the correlation between the amount of incisor retractions and lower facial height and soft tissue in the Pearson correlation.

Based on the results shown in table 2, no significance was found (p > 0.05) between the maxillary incisor retraction and lower facial height and the upper lip thickness as well as mandibular incisor retraction with lower facial height and lower lip thickness. A strong positive correlation (r = 0.8 – 1.0) is shown in maxillary incisor retraction with upper lip anteroposterior position (r = 0.902). Moreover, a strong positive correlation is also found (r = 0.60 – 0.79) in maxillary incisor upper lip retraction with upper lip angle (r = 0.775) and nasolabial angle (r = 0.647).

Simple regression analysis shows that maxillary incisor retraction at 1 mm caused 1.034 mm upper lip retraction. Then, the retraction of the mandibular incisor by 1 mm caused retraction of the lower lip by 0.132 mm.

![Table 1. Measurement results of pre- and post-treatment](image)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Changes</th>
<th>n</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Maxillary incisor distance (mm)</td>
<td>-4.57</td>
<td>1.10</td>
<td>-10.11</td>
<td>1.29</td>
<td>-5.54</td>
</tr>
<tr>
<td>Mandibular incisor distance (mm)</td>
<td>-8.80</td>
<td>0.99</td>
<td>-12.78</td>
<td>1.28</td>
<td>-3.98</td>
</tr>
<tr>
<td>Lower facial height (mm)</td>
<td>80.56</td>
<td>1.21</td>
<td>79.72</td>
<td>1.27</td>
<td>-0.83</td>
</tr>
<tr>
<td>Upper lip distance (mm)</td>
<td>6.85</td>
<td>0.89</td>
<td>4.19</td>
<td>0.99</td>
<td>-2.65</td>
</tr>
<tr>
<td>Lower lip distance (mm)</td>
<td>4.37</td>
<td>1.40</td>
<td>0.87</td>
<td>1.38</td>
<td>-3.50</td>
</tr>
<tr>
<td>Upper lip thickness (mm)</td>
<td>13.83</td>
<td>0.60</td>
<td>14.11</td>
<td>0.66</td>
<td>0.28</td>
</tr>
<tr>
<td>Lower lip thickness (mm)</td>
<td>12.14</td>
<td>0.68</td>
<td>12.69</td>
<td>0.82</td>
<td>0.54</td>
</tr>
<tr>
<td>Upper lip angle (°)</td>
<td>23.36</td>
<td>2.27</td>
<td>14.84</td>
<td>2.49</td>
<td>-8.52</td>
</tr>
<tr>
<td>Nasolabial angle (°)</td>
<td>88.12</td>
<td>2.57</td>
<td>96.72</td>
<td>2.71</td>
<td>8.60</td>
</tr>
</tbody>
</table>

* Significant difference (p < 0.05)
Diagnosis and treatment planning are necessary for the successful treatment of malocclusions. However, facial aesthetics do not only depend on hard tissue, as the analysis alone is inadequate. This is a result of the various thicknesses of soft tissue, the length of the lips and tissue posture. Cephalometry analysis of soft tissue is a method used to measure facial disharmony and identify the cause of it. It can be stated this way: a good facial aesthetic is achievable if the root problems can be identified and treated. Among the analyses for soft tissue, Arnett analysis is a combination of hard and soft tissue used to evaluate upper, middle and lower facial structures.

Orthodontic treatment by premolar extraction aims to resolve tooth and arch size discrepancy to allow correction of anterior teeth inclination or to reduce facial vertical height. Based on the results of this study, premolar teeth extraction followed by incisor retraction at either the maxillary or mandibular does not provide significant statistical changes for the lower facial height. This result aligns with the study done by Ramesh in which the changes in vertical height in a high-angle case using premolar teeth extraction were measured. The result shows no significant changes at TAFH (total anterior facial height) and LAFH (lower anterior facial height) variables.

Research done by Zafarmand states that premolar teeth extraction (either four or two premolar teeth) to reduce facial height does not provide significant changes to the patients after treatment. Chua et al. studied the effect of extraction and non-extraction to LAFH and while they reported a significant increase in the non-extraction group, there was no significant difference in the group with extraction. Cusimano, McLaughlin et al. did not find any difference in facial height in hyperdivergent patients with first premolar extraction and wrote that an increase in vertical dimension along with the growth and development that was caused by the extrusion during molar tooth movement to mesial.

This study aligns with research done by Pearson and Schudy, who stated that the coverage of extraction space might be caused by the movement of molar tooth to mesial. This results in the decrease in vertical dimension and mandibular angle. A study by Issacson and Ulgen reported that the movement of a molar tooth to mesial

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**Table 2.** The correlation between incisor retraction and lower facial height and soft tissue

<table>
<thead>
<tr>
<th>Variable</th>
<th>Maxillary incisor retraction</th>
<th>Mandibular incisor retraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>$p$</td>
</tr>
<tr>
<td>Lower facial height (mm)</td>
<td>0.144</td>
<td>0.491</td>
</tr>
<tr>
<td>Anteroposterior upper lip position (mm)</td>
<td>0.959*</td>
<td>0.000</td>
</tr>
<tr>
<td>Anteroposterior lower lip position (mm)</td>
<td>0.460</td>
<td>0.021</td>
</tr>
<tr>
<td>Upper lip thickness (mm)</td>
<td>0.192</td>
<td>0.358</td>
</tr>
<tr>
<td>Lower lip thickness (mm)</td>
<td>0.404</td>
<td>0.045</td>
</tr>
<tr>
<td>Upper lip angle (°)</td>
<td>0.775*</td>
<td>0.000</td>
</tr>
<tr>
<td>Nasolabial angle (°)</td>
<td>0.647*</td>
<td>0.000</td>
</tr>
</tbody>
</table>

* Correlation significant at 0.000 level.

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**Discussion**

Diagnosis and treatment planning are necessary for the successful treatment of malocclusions. However, facial aesthetics do not only depend on hard tissue, as the analysis alone is inadequate. This is a result of the various thicknesses of soft tissue, the length of the lips and tissue posture. Cephalometry analysis of soft tissue is a method used to measure facial disharmony and identify the cause of it. It can be stated this way: a good facial aesthetic is achievable if the root problems can be identified and treated. Among the analyses for soft tissue, Arnett analysis is a combination of hard and soft tissue used to evaluate upper, middle and lower facial structures.

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This study aligns with research done by Pearson and Schudy, who stated that the coverage of extraction space might be caused by the movement of molar tooth to mesial. This results in the decrease in vertical dimension and mandibular angle. A study by Issacson and Ulgen reported that the movement of a molar tooth to mesial
without extrusion causes mandibular anterior rotation. Pearson stated that the movement of a posterior tooth to mesial causes reduction in the SN/MP angle.\textsuperscript{5} The major complaints of malocclusion in bimaxillary protrusion are incisor tooth and lip protrusion.\textsuperscript{3} Kusnoto predicted the changes in soft tissue profile are achieved after orthodontic treatment, especially in cases of malocclusion with bimaxillary protrusion.\textsuperscript{16} The treatment assumes that the upper and lower lips will move back, while the nasolabial angle will increase as a result of maxillary and mandibular incisor retraction. Consequently, the facial procumbency is reduced.\textsuperscript{5,16} According to Lai et al. and Oliveira et al., there is a wide variation of soft tissue response, and it is difficult to predict or correlate perfectly to alter tooth position.\textsuperscript{2}

In this study, maxillary tooth incisor retraction causes significant changes in posterior movement of the upper lip, decrease of the upper lip angle and increase of the nasolabial angle. This aligns with the research conducted by Kocadereli, who stated that the retraction causes an alteration in lip position and reduces facial convexity.\textsuperscript{8} Similarly, the study done by Khurshid et al. stated that the extraction of the first four premolar teeth followed by anterior retraction is able to reduce tooth and soft tissue procumbency in the Kashmir population with bimaxillary protrusion.\textsuperscript{6} Next, a 1 mm maxillary incisor retraction will produce a 1.034 mm retraction of the upper lip. This is similar to research by Yasutomi et al. that analyzed lateral cephalometry radiograph pre- and post- treatment of 38 patients with Class I Angle bimaxillary protrusion treated by extraction of the first four premolar teeth. The report shows the ratio of maxillary incisor retraction and upper lip retraction is 1.85:1.\textsuperscript{9} A study by Nanda shows maxillary incisor retraction of 3.1 mm caused the upper lip to move inward by 1.9 mm.\textsuperscript{8} Furthermore, research conducted by Arumugam et al. shows maxillary incisor retraction of 2.9 ± 2.8 mm has resulted in upper lip retraction of 0.9 ± 1.7 mm with a ratio of 3:1, whereas mandibular incisor retraction of 1.6 ± 2.0 mm caused upper lip retraction of 1.1 ± 2.7 mm with a ratio of 1.5:1.\textsuperscript{11} The retraction of the maxillary incisor by 1 mm has also caused the decrease of the upper lip angle by 0.611° and the increase of the nasolabial angle by 0.327°. The result aligns with research by Lo and Hunter, which reports that the bigger the retraction of maxillary incisor is, then the higher the rise of the nasolabial angle.\textsuperscript{7} The changes to the nasolabial angle reduce teeth procumbency.\textsuperscript{3}

There are no changes in upper lip thickness from maxillary incisor retraction in this study, similarly with the study done by Kojo et al. On the contrary, Kasai’s study shows a relationship between incisor and lips thickness.\textsuperscript{17} According to Kojo et al., the significant increase in upper and lower lips thickness was based on a T-paired test. This was not caused by the tension during the retraction.\textsuperscript{9} The probability of lip thickness is from the relaxation of the lip muscles that occurs after incisor retraction. Moreover, mandibular incisor retraction also causes a significant posterior movement of the lower lip with a ratio of 1:0.132. Study showed that the decrease of Md1 by 3.87 mm, with lower lip reduced by 3.46 mm and with a ratio of 1.12:1 for mandibular incisor and lower lip retractions.\textsuperscript{9} This study has no changes to lower lip thickness as a result of mandibular incisor retraction.

**Conclusion**

In the case of bimaxillary protrusion, orthodontic treatment comprising the extraction of the first four premolar teeth causes movements to the posterior of lips, a decrease in the upper lip angle and an increase in the nasolabial angle. Therefore, the procumbency in the facial profile is reduced.

**Acknowledgment**

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**Conflict of Interest**

The authors declare that there are no conflicts of interest.

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