ORIGINAL ARTICLE

EFFECT OF INCISOR INCLINATION CHANGES ON CEPHALOMETRIC POINTS A AND B

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Background: The position of cephalometric points A and B are liable to be affected by alveolar remodelling caused by orthodontic tooth movement during incisor retraction. This study was conducted to evaluate the change in positions of cephalometric points A and B in sagittal and vertical dimensions due to change in incisor inclinations. Methods: Total sample of 31 subjects were recruited into the study. The inclusion criteria were extraction of premolars in upper and lower arches, completion of growth and orthodontic treatment. The exclusion criteria were patients with craniofacial anomalies and history of orthodontic treatment. By superimposition of pre and post treatment tracings, various linear and angular parameters were measured. Various tests and multiple linear regression analysis were performed to determine changes in outcome variables. Statistically significant p-value was ≤0.05. Results: One-sample t-test showed that change in position of only point A was statistically significant which was 1.61mm (p<0.01) in sagittal direction and 1.49mm (p<0.01) in vertical direction. Multiple linear regression analysis showed that if we retrocline upper incisor by 10°, the point A will move superiorly by 0.6mm. Conclusions: Total change in the position of point A is in a downward and forward direction. Total change in upper incisors inclinations causes change in position of point A only in vertical direction.

Keywords: Incisor inclination, Point A, Point B, cephalometric

INTRODUCTION

Points A and B are commonly used to scrutinize the sagittal relationship of maxilla and mandible during formulation of precise diagnosis. These points also facilitate us to inspect the true efficacy of various treatment protocols on skeletal jaw bases in sagittal direction. Many linear parameters have been suggested to evaluate the anteroposterior (AP) relationship of jaws: (1) the distance between perpendiculars drawn from the sella-nasion line to points A and B, (2) the distance between perpendiculars drawn from the occlusal plane to points A and B (Wits appraisal), (3) the AP dysplasia indicator, (4) the distance between nasion perpendiculars drawn from the Frankfort plane to points A and B, (5) the distance between perpendiculars drawn from the palatal plane to points A and B, (6) the distance between perpendiculars drawn from the bisector of the maxillo-mandibular plane angle to points A and B.

Nevertheless, these measurements still use points A and B as reference points for the AP position of maxilla and mandible, respectively. The positions of cephalometric points A and B are liable to be affected by growth as well as dentoalveolar remodelling caused by orthodontic treatment. Erverdi testified borderline significant correlation between axial inclination of maxillary incisors and the position of point A but did not state the p-value. The simple linear regression analysis, used in the study, proposed that there is 0.16mm of change in the position of point A in posterior direction when the tooth is proclined by 1°. However, statistical method of analysis did not account for growth. Furthermore, to rule out measurement errors, no repeatability analysis was performed.

Al-Abdwan stated that each 10° retroclination of maxillary incisors results in statistically significant advancement of point A of 0.4 mm in horizontal plane. In addition, each 10° retroclination of mandibular incisor results in borderline statistically significant advancement of point B of 0.3 mm in horizontal plane. The study used a multiple linear regression analysis to analyse the data accounting for change in the position of points A and B due to growth and bodily tooth movement for each subject ranging from 8.8 to 39 years. However, even after the consideration of growth, the validity of study on individuals of such age variation may be questionable and this may affect the accuracy of the results. Moreover, the above mentioned studies did not consider the incisor retraction into extraction spaces.

The aim of this study is to evaluate the change in position of points A and B purely due to the incisal inclination changes because of orthodontic treatment in adult patients.

MATERIAL AND METHODS

The material employed in this cross-sectional cephalometric study comprised of 31 pairs of pre and post treatment lateral cephalographs of non-syndromic patients (3 males and 28 females) who had finalized
their orthodontic treatment. All radiographs had been taken as a part of the standard clinical procedure for diagnosis and treatment planning. These radiographs were procured on the same cephalostat and they were of sufficient quality to allow recognition of relevant landmarks on their tracings.

The inclusion criteria for the subjects to be recruited in the study were extraction of premolars in upper and lower arches and adult patients of Pakistani origin. The exclusion criteria of the study were patients having history of orthodontic treatment. The x-ray films were selected from orthodontic department system fulfilling the above mentioned inclusion criteria and were traced over an illuminator manually by the principal investigator. All the landmarks were identified based on the definitions by Riolo et al.\textsuperscript{12} except gonion \textsuperscript{13} (Table-1). Pre-treatment lateral cephalometric radiographs were traced with solid lines while post treatment cephalograms were traced with dashed lines. Data was taken from all the files meeting the inclusion criteria from the period 2002–2009.

The following parameters were used in this study as illustrated in figure-1:

- Upper incisor angle to Sella-Nasion plane (UI-SN\textsuperscript{a}):
  Angle formed the intersection of the long axis of the maxillary incisor and Sella-Nasion (SN) line
- Lower incisor angle to mandibular plane (IMPA\textsuperscript{a}):
  Angle formed by the intersection of the long axis of mandibular incisor with the Gonion-Menton line
- Change in UI-SN\textsuperscript{b}:
  Change in the UI-SN angle between pretreatment and post treatment lateral cephalographs
- Change in IMPA\textsuperscript{b}:
  Change in IMPA angle between pretreatment and post treatment lateral cephalographs
- \(A_V\): Total vertical displacement covered by cephalometric point A
- \(A_H\): Total horizontal displacement covered by cephalometric point A
- \(B_V\): Total vertical displacement covered by cephalometric point B
- \(B_H\): Total horizontal displacement covered by cephalometric point B

By superimposition of pre and post treatment lateral cephalographs, total change in positions of points A and B were evaluated. The negative sign was used for upward as well as for backward displacement of point A or B during data collection.

For assessment of total change in position of point A, pre and post treatment tracings were superimposed on the sella-nasion (SN) line at the sella as illustrated in Figure II. On this superimposition, a horizontal line passing through sella, 7 degrees inferior from the SN line, was drawn to form a horizontal reference plane (HRP).\textsuperscript{14} A line perpendicular to HRP passing through sella established the vertical reference plane (VRP).\textsuperscript{14}

To determine the total vertical displacement of point A (\(A_V\)), two horizontal lines, perpendicular to VRP, were drawn on both tracings, passing through pre and post treatment point A, and were labelled as \(H_1\) and \(H_2\), respectively. The vertical distance between these two horizontal lines defined the vertical component of change in position of point A. To determine the total horizontal displacement of point A (\(A_H\)), two vertical lines, perpendicular to HRP, were drawn on both tracings, passing through pre and post treatment point A, and were labelled as \(V_1\) and \(V_2\), respectively. The horizontal distance between these two vertical lines determined the AP component of change in position of point A (Figure-2).

For calculation of total change in position of point B, pre and post treatment tracings were superimposed on lingual contour of the symphysis in order to control the confounder of mandibular rotation as illustrated in figure III. Similarly, HRP and VRP were sketched on a superimposition tracing.

Determine the total vertical displacement of point B (\(B_V\)), two horizontal lines, and perpendicular to VRP, were drawn on both tracings, passing through pre and post treatment point B, and were labelled as \(H_3\) and \(H_4\), respectively. The vertical distance between these two horizontal lines defined the vertical component of change in position of point B. To determine the total horizontal displacement of point B (\(B_H\)), two vertical lines, perpendicular to HRP, were drawn on both tracings, passing through pre and post treatment point B, and were labeled as \(V_3\) and \(V_4\), respectively. The horizontal distance between these two vertical lines determined the AP component of change in position of point B (Figure-3).

Means and standard deviations were computed for all the variables using Statistical Package for the Social Sciences (SPSS) for windows (version 19.0 Chicago Inc. USA). Paired sample \(t\)-test was performed to determine the total change in angular parameters during the treatment. One-sample \(t\)-test was applied to evaluate the total change in position of points A and B.

Multiple linear regression analysis was performed to assess the relationship of change in position of points A and B with the remaining variables, keeping the change in position of points A and B as dependent variables and the remaining parameters as independent variables, alternatively, \(p\)-value less than or equal to 0.05 was considered as statistically significant.

To rule out measurement error, 10 lateral cephalometric radiographs were retraced after 1 month by the principal investigator and Pearson correlation was applied which showed strong and positive correlations (Table-2).
RESULTS

Out of total number of 31 subjects, 28 were females and 3 were males. Mean age of patients was 17.72±5.08 years. Treatment changes for angular parameter are shown in table-3 and for linear parameters are shown in table-4.

The maxillary incisor inclination change ranged from pre-treatment 111.94±5.50° to post treatment 103.23±9.15° (p=0.001). The mandibular incisor inclination change ranged from pre-treatment 102.19±7.16° to post treatment 98.13±7.16° (p=0.001). The total change in the position of point A was in a downward and forward direction. Total vertical displacement of point A was 1.49±1.94 mm (p=0.001) and total horizontal displacement was 1.61±2.20 mm (p=0.001). The total change in position of point B was in upward and backward direction but it was not statistically significant. Total vertical displacement of point B was -0.54±2.64 mm (p=0.26) and total horizontal displacement was -0.01±1.06 mm (p=0.94).

The results of multiple linear regression analysis are shown in table-5. The results provide evidence that each 10° retroclination of maxillary incisor results in a borderline statistically significant displacement of point A of 0.6 mm in upward direction and conversely, each 10° proclination of maxillary incisor results in borderline statistically significant displacement of point A of 0.6 mm in downward direction (p=0.06). There was no evidence that incisal inclination changes result in significant changes in horizontal position of point A (p=0.41) and, vertical (p=0.7) and horizontal (p=0.4) position of point B.

Figure-1: Illustration of various landmarks, planes and angles

Figure-2: Illustration of superimposition of pre and post treatment tracings at point sella for determination of change in position of point A

Figure-3: Illustration of superimposition of pre and post treatment tracings on lingual contour of symphysis for determination of change in position of point B
changes, which are lower incisor inclination changes, suggest that the most useful approach is to superimpose at various sites and marks, which does not in fact lie on the anterior cranial base but at the outer limit of the frontal bone, which does not correspond to the lateral limit of the nasal cavity. J Ayub Med Coll Abbottabad 2015;27(2). Table 1: Cephalometric landmarks, reference planes, and angular measurements

<table>
<thead>
<tr>
<th>Landmark, Plane or Angle</th>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sella</td>
<td>S</td>
<td>Centre of the pituitary fossa of the sphenoid bone</td>
</tr>
<tr>
<td>Nasion</td>
<td>N</td>
<td>Junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose</td>
</tr>
<tr>
<td>A point</td>
<td>A</td>
<td>Most posterior point on the curve of the maxilla between the anterior nasal spine and supradentale</td>
</tr>
<tr>
<td>B point</td>
<td>B</td>
<td>Most posterior point to a line from infradentale to pogonion on the anterior surface of the symphysial outline of the mandible</td>
</tr>
<tr>
<td>Menton</td>
<td>Me</td>
<td>Most inferior point on the symphysial outline of the mandible</td>
</tr>
<tr>
<td>Gonion</td>
<td>Go</td>
<td>Bisector of the angle between tangent through the posterior margin of the ascending ramus and tangent to the mandibular base at menton</td>
</tr>
<tr>
<td>Upper incisor apex</td>
<td>UIA</td>
<td>Incisal apex of the most prominent upper central incisor</td>
</tr>
<tr>
<td>Upper incisor edge</td>
<td>UIE</td>
<td>Incisal edge of the most prominent upper central incisor</td>
</tr>
<tr>
<td>Lower incisor edge</td>
<td>LIE</td>
<td>Incisal edge of the most prominent lower central incisor</td>
</tr>
<tr>
<td>Lower incisor apex</td>
<td>LIA</td>
<td>Incisal apex of the most prominent lower central incisor</td>
</tr>
<tr>
<td>Upper incisor axis</td>
<td>UI</td>
<td>Line drawn through UIA and UIE</td>
</tr>
<tr>
<td>Lower incisor axis</td>
<td>I</td>
<td>Line drawn through LIE and LIA</td>
</tr>
<tr>
<td>Sella-nasion</td>
<td>SN</td>
<td>Plane through sella and nasion</td>
</tr>
<tr>
<td>Mandibular plane</td>
<td>MP</td>
<td>Plane drawn through Me and Go</td>
</tr>
<tr>
<td>Horizontal reference plane</td>
<td>HRP</td>
<td>Horizontal reference plane was constructed at 7° inferior to SN</td>
</tr>
<tr>
<td>Vertical reference plane</td>
<td>VRP</td>
<td>Vertical reference plane was drawn as a perpendicular to HRP at sella</td>
</tr>
</tbody>
</table>

Table 2: Summary table showing correlations to assess intra-examiner reliability

<table>
<thead>
<tr>
<th>Variables</th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPA</td>
<td>93.1</td>
<td>0.001 *</td>
</tr>
<tr>
<td>UI-SN</td>
<td>88.9</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Aa</td>
<td>99.9</td>
<td>0.001</td>
</tr>
<tr>
<td>Ab</td>
<td>98.3</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Bc</td>
<td>98.1</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Bp</td>
<td>98.2</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Pearson correlation

Table 3: Treatment changes in angular parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean±SD (degrees)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPA*</td>
<td>102.19±7.16</td>
<td>0.001</td>
</tr>
<tr>
<td>UI-SN*</td>
<td>111.94±5.50</td>
<td>0.001</td>
</tr>
</tbody>
</table>

n=31, IMPA = Incisor-Mandibular Plane Angle; Paired-sample t-test, UI-SN = Upper Incisor-SN Plane Angle, p<0.01

Table 4: Treatment changes in linear parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean Distance±SD (mm)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aa</td>
<td>1.49±1.94</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Ab</td>
<td>1.61±2.20</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Bc</td>
<td>0.54±2.64</td>
<td>0.26</td>
</tr>
<tr>
<td>Bp</td>
<td>-0.01±1.06</td>
<td>0.94</td>
</tr>
</tbody>
</table>

n=31, Aa = Total vertical displacement of point A, Ab = Total horizontal displacement of point A, Bc = Vertical displacement of point B, Bp = Total horizontal displacement of point B

Table 5: Results of multiple linear regression analysis for the effect of maxillary and mandibular incisor inclination changes on position of points A and B in horizontal and vertical directions

<table>
<thead>
<tr>
<th>Effect of incisal inclination change on:</th>
<th>Coefficient (mm per degree of inclination change)</th>
<th>p-value</th>
<th>95% Confidence Interval Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point A in vertical direction</td>
<td>-0.06</td>
<td>0.06</td>
<td>-0.24</td>
<td>0.01</td>
</tr>
<tr>
<td>Point A in horizontal direction</td>
<td>-0.06</td>
<td>0.41</td>
<td>-0.21</td>
<td>0.09</td>
</tr>
<tr>
<td>Point B in vertical direction</td>
<td>0.02</td>
<td>0.7</td>
<td>-0.19</td>
<td>0.15</td>
</tr>
<tr>
<td>Point B in horizontal direction</td>
<td>-0.03</td>
<td>0.4</td>
<td>-0.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

n=31, p≤0.05, *Minus sign indicate opposite effect of incisal inclination change

DISCUSSION

Changes in the positions of points A and B may be due to skeletal changes, which result from movement of maxilla and mandible relative to anterior cranial base (growth), and local changes, which are instigated by local bone remodelling associated with changes in upper and lower incisor inclination during orthodontic treatment. The purpose of this study was to evaluate the position of points A and B associated with upper and lower incisor inclination changes, respectively. In this study, adult patients were procured in order to account for the skeletal changes.

In order to consider the local changes due to dentoalveolar remodelling, methods of superimposition at various structures have been used for many years. Unfortunately, the maxilla is subjected to extensive periosteal remodelling, and no really satisfactory stable sites are available for superimposition. Proffit suggested that the most useful approach is to superimpose on the SN line, registering the template over the patient’s tracing at the nasion rather than the sella if there is a difference in cranial base length. On the other hand, Houstn found that this line undergoes little change from growth or remodelling after about 6 years of age, when the sphenoid synchondrosis fuses; he also mentioned that unfortunately, the nasion does not in fact lie on the anterior cranial base but at the outer limit of the frontonasal suture, which does not correspond to the lateral limit of the nasal cavity.
remodel with growth. Thus, an incorrect impression of the way the face has grown will be obtained if serial radiographs are related to one another by means of this line with registration at the nasion. He suggested that superimposition on the SN line with registration at the sella usually yields a reliable picture of overall facial change.

In our study, we found that total change in the position of point A after orthodontic treatment, relative to cranial base, was in downward and forward direction. Total vertical displacement of point A was 1.49±1.94 mm (p=0.001) and total horizontal displacement was 1.61±2.20 mm (p=0.001). These findings are in concordance to Al-Nimri et al17 who found that movement of point A, relative to cranial base, was in a downward and forward direction.

Few studies2,18 have also been attempted to investigate the effect of root torque of upper incisors on position of point A. Ciangioli and Meistrell8 studied changes associated with palatal root torque of the upper incisor and point A in adolescent patients. They demonstrated statistically significant correlation between changes in upper incisor root position and point A as they moved posteriorly by 1.7 mm and 3.5 mm, respectively. Similarly, Goldin18 compared the effect of labial root torque on point A in 17 subjects to a matched control group in an attempt to account for growth. He found that labial root torque resulted in an increase in skeletal convexity. We have taken all the extraction cases in which anterior teeth retraction was mainly done by bodily movement that is why our study did not consider the effect of root torque on position of point A.

In this study, all the subjects meeting the inclusion criteria have been taken regardless of their malocclusion. There have been some studies19-21 which state that in class II division 2 malocclusion, SNA angle is affected at the end of the treatment due to change in position of point A. Arvysts19-20 presented two cases of nonextraction treatment of severe Class II division 2 malocclusion; at the end of treatment, he noticed that the SNA angle was reduced. In addition, Cleall and BeGole21 also noted that the SNA angle was reduced in Class II division 2 malocclusion. However, Al-Nimri et al17 found that change in position of point A was so small that it did not affect the value of SNA angle.

To analyse the effect of incisor inclination changes on position of point A, various studies11,17 have been conducted. Our study reports that total changes in position of point A, relative to upper incisor inclination changes of 10°, were marginally statistically significant of 0.6 mm in upward direction (p=0.06). These findings are in contrast to Al-Abdwani et al11 who found insignificant results for change in position of point A due to upper incisor inclination changes in vertical direction.

Al-Abdwani et al11 reported significant results for change in position of point A due to incisor inclination changes in horizontal direction. They demonstrated that each 10° retroclination of the maxillary incisor results in statistically significant advancement of point A of 0.4 mm in the horizontal plane and vice versa (p=0.028). Similarly, Erverdi10 reported that there is a significant correlation between the axial inclination of the upper incisors and the position of point A. However, we found an insignificant difference in the position of point A in horizontal direction.

For the evaluation of change in position of point B with reasonable accuracy, pre and post treatment tracings were superimposed on lingual contour of symphysis. According to Sazmann12 superimposition on lingual contour of symphysis is more reliable and acceptable method to appraise the treatment effects relative to mandible. True mandibular rotation is greater during transition to the early mixed dentition than adolescents and even at any time thereafter.23-24 Although, the amount of mandibular rotation in adulthood is less than that of adolescence but it might confound the results. Thus, to control the confounder of mandibular rotation, superimposition of tracings was done on lingual contour of symphysis.

In our study, we found that the total change in position of point B after orthodontic treatment, relative to cranial base, was in upward and backward direction but it was not statistically significant. Total vertical displacement of point B was -0.54±2.64 mm (p=0.26) and total horizontal displacement was -0.01±1.06 mm (p=0.94). The negative sign indicates that change in position of point B was in upward and backward direction.

As far as change in position of point B due to incisor inclination changes is concerned, we found insignificant results for both in the horizontal and vertical direction. This may be in consequence of a small sample size. There is a higher possibility that one can find a significant relationship of change in position of point B due to lower incisor inclination changes with a larger sample size. Al-Abdwani et al11 also reported that there is no evidence of significant vertical displacement of point B due to lower incisor inclination changes. However, they found borderline significant relationship for horizontal displacement of point B. They demonstrated that each 10° change in lower incisor inclination causes 0.3 mm horizontal displacement of point B in the opposite direction. It means retroclining the lower incisors by 10°, point B will move in backward direction by 0.3 mm and vice versa.
The results of the study suggest that change in maxillary and mandibular incisor inclinations during orthodontic treatment affects the position of only point A due to dentoalveolar remodelling. But the magnitude of change in the position of this skeletal landmark is not immense enough to be clinically consequential.

CONCLUSIONS

• The total change in position of point A is in downward and forward direction
• There is no evidence of change in position of point B in any direction
• Change in upper incisor inclination causes change in position of cephalometric point A only in vertical direction
• Change in lower incisor inclination is not significantly related to the change in position of cephalometric point B

REFERENCES

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