A New Method for Assessment of Sagittal Dysplasia—E Analysis

Objective: To develop a new cephalometric linear measurement to evaluate anteroposterior relationship between the maxilla and mandible.

Materials and methods: Seventy-five pretreatment cephalometric radiographs of patients between the ages of 17 and 25 years were selected. They were subdivided into Class I, II and III groups (25 each) based on the ANB angle, Wits appraisal and Beta angle. The new measurements are based on the landmarks PTM, M (midpoint of anterior maxilla), and D (Midpoint of symphysis). The E analysis consists of three linear measurements, the effective length of maxillary base (M-HPp), the effective length of mandibular base (D-HPp) and sagittal dysplasia indicator (M-HPp – D-HPp).

Results: Means and standard deviations of the each variable in E analysis among all the three groups were calculated. The result showed that mean value of M-HPp and D-HPp for skeletal Class I group were 46.18 mm with a SD of 3.4 and 45.82 mm with an SD of 3.7 respectively for Kerala population. M-HPp minus D-HPp value for skeletal Class I group was 0.38 with a SD of 0.76. There was no statistically significant difference between males and females. Cut-off point of M-HPp minus D-HPp between Class I and II was at 1.75 mm and between Class I and III at –1.5 mm. There were statistically significant correlations between M-HPp minus D-HPp and ANB, Wits appraisal, and Beta angle.

Conclusion: E analysis is effective in assessing the sagittal jaw dysplasia. Comparing M-HPp and D-HPp with the norms of skeletal Class I, E analysis can be used to assess which jaw was retrognathic or prognathic.

Keywords: Effective length of mandibular base, Effective length of maxillary base, E analysis, Sagittal dysplasia indicator.


Source of support: Nil

Conflict of interest: None

INTRODUCTION

One of the important steps in orthodontic diagnosis and treatment planning is to evaluate the sagittal apical base relationship, and which is usually determined by cephalometric analysis. Various angular and linear measurements have been proposed to assess apical base relationship between maxilla and mandible. Both the angular and linear measurements have its own advantages and disadvantages, which have been described by Moyers et al.

First attempt to describe apical base relationship was done by Wylie in 1947. Following that various other cephalometric methods have been proposed. Down’s evaluated the apical base relationship cephalometrically by measuring the angle formed by AB and Npog. Later Riedel introduced ANB angle to describe apical base relationship. This has been the most frequently used method for evaluating sagittal discrepancy.

According to Jacobson, ANB angle is subjected to the anteroposterior spatial relationship of nasion relative to jaws and also to rotational effect of the jaws relative to cranial reference lines. So, ANB angle does not represent the true apical base relationship. To overcome the limitations of angle ANB, Jacobson introduced Wits appraisal. Since it uses occlusal plane to describe the sagittal dysplasia, any change in angulation of the occlusal plane influences the position of A and B and thereby the Wits appraisal reading. The occlusal plane can also be affected by dental development, tooth eruption and by orthodontic tooth movement. Nanda and Moyers advocated a conjunctive use of the ANB angle and the Wits appraisal due to these geometric effects.

In 1987, Chang introduced a method to assess the sagittal discrepancy by measuring the distance between A and B projected onto the Frankfort horizontal plane as AF and BF respectively and AF-BF gives the sagittal discrepancy. Since the reference plane used in this method is Frankfort horizontal plane, it can be affected by its inclination.

Nanda and Merrill suggested angles or linear measurements based on the palatal plane. The inclination of palatal plane is highly variable which may affect in assessing the true apical base relationship.
Baik and Ververidou\textsuperscript{14} developed the Beta angle, which is independent of the cranial reference plane or occlusal plane. Though, it assesses the apical base relationship, it depends on points A, B and Co. Previous studies \textsuperscript{9,15,16} suggested that point A is affected by alveolar bone remodeling associated with orthodontic tooth movement and the other problem is the difficulty in reproducing the location of condyle on mouth-closed lateral cephalogram.\textsuperscript{17-19}

Neela et al\textsuperscript{20} introduced the YEN angle, which is an angle between the line SM and MG. Similar to ANB angle, the rotation of jaws because of the growth or orthodontic treatment can change true basal dysplasia.

Recently, WA Bhad et al\textsuperscript{21} introduced a new approach to assess the sagittal dysplasia, i.e. the W angle, which is measured between a perpendicular line from point M to the S-G line and M-G line. Though W angle remains relatively stable even when the jaws are rotated or growing vertically, it cannot determine which jaw is prognathic or retrognathic.

To overcome these problems, this study was conducted to develop a new method to evaluate apical base relationship and to assess whether discrepancy is due to prognathic or retrognathic jaw.

**E ANALYSIS**

E analysis consists of three linear measurements, the effective length of maxillary base (M-HPp), the effective length of mandibular base (D-HPp) and sagittal dysplasia indicator (M-HPp – D-HPp) (Fig. 1). The name is chosen as E analysis, because three horizontal lines, i.e. THL, M-HPp and D-HPp along with perpendicular line HPp resembles the alphabet ‘E’.

**Measuring Points**

- Pterygomaxillary (PTM) fissure—apex of the teardrop-shaped pterygomaxillary fissure.
- Point M (M)—midpoint of premaxilla. M point is constructed at the center of the largest circle placed tangent to the anterior, superior and palatal surfaces of the premaxilla.\textsuperscript{13}
- Point D (D)—point at the center of the mass of the symphysis.

**Reference Lines**

- True vertical line (TVL)—a line drawn from the radiographic image of the vertical metallic scale in the digital lateral cephalogram.
- True horizontal line (THL)—a line perpendicular to the true vertical line passing through the 10 mm mark in the vertical metallic scale.
- Horizontal plane perpendicular (HPp)—a line perpendicular to THL through PTM.

**Measuring Procedures**

For the linear measurements on the standardized lateral cephalograms obtained in natural head position, the THL and the HPp were used as a reference line. Several researchers have concluded that natural head position is the logical reference and orientation position for the evaluation of craniofacial morphology.\textsuperscript{22,23} All measurements were done perpendicular to the HPp. E analysis comprised the following measurements:

- M-HPp: The effective length of maxillary base.
- D-HPp: The effective length of mandibular base.

The aims of the present study were to:

1. Provide the mean values and standard deviations for the effective length of maxillary base (M-HPp).
2. Provide the mean values and standard deviations for the effective length of mandibular base (D-HPp).
3. Provide the mean values and standard deviations for the sagittal dysplasia indicator for a sample of skeletal Class I, II and III males and females.
4. To examine the sensitivity and specificity of the sagittal dysplasia indicator, M-HPp – D-HPp to discriminate among the three skeletal pattern groups.
5. Whether there is any significant difference between males and females in each skeletal Class I, II and III.
6. Assess the correlation between M-HPp–D-HPp and ANB angle, Wits appraisal and Beta angle.

MATERIALS AND METHODS

All the samples of skeletal Class I, II and III pattern groups, within age of 17 to 25 years were selected from the Department of Orthodontics and Dentofacial Orthopedics, Mar Baselios Dental College, Kothamangalam, Kerala, India. The sample group consisted of total 75 pretreatment lateral cephalograms of 17 to 25 years old individuals selected from our department.

The same cephalostat with mirror eye and true vertical reference was used for all subjects to obtain lateral cephalometric radiographs in natural head position. In all subjects, for further verification of NHP, a simple split level bubble device was attached between the eyebrow and the hairline behind the prominent temporal crest of the frontal bone (Fig. 2). The subjects were instructed to stand upright, with arms at his or her sides, and look into the mirror. The patient head was tilted up or down until the bubble get aligned in the middle of the device.

All lateral cephalograms were retraced after the initial selection; the ANB angle, Wits appraisal and Beta angle were measured. Skeletal Class I group consisted of 25 lateral cephalograms. Each patient in the group satisfied a minimum of the two parameters out of the three (ANB angle, Wits appraisal, Beta angle). An ANB angle of 2 to 4°, a Wits coincidence of AO and BO in females or BO 1 mm ahead of AO in males, and Beta angle of 27 to 35° were indicated in skeletal Class I group.

Similarly, skeletal Class II relationship was indicated by an ANB angle greater than 4°, a Wits appraisal with AO ahead of BO and a Beta angle less than 27°. Skeletal Class II group also consisted of 25 lateral cephalograms.

Skeletal Class III individuals were characterized by an ANB angle less than 2°, a Wits BO ahead of AO by more than 1 mm and a Beta angle greater than 35°. Twenty-five lateral cephalogram were included in skeletal Class III group with meeting the above criteria.

For the construction of the analysis, points PTM, M and D were located. Points PTM and D were eyeballed and point M was constructed using a template with concentric circles whose diameter increased in 1 mm increments, as proposed by Nanda and Merill.

After classifying the groups, M-HPp, D-HPp and M-HPp–D-HPp were measured by two operators and mean value was taken. Twenty-five randomly selected cephalograms were retraced after few days of first evaluation. Between the first and second measurement, there was no statistically significant difference. Intraclass agreement coefficient test showed excellent agreement with M-HPp and D-HPp of 98.7 and 98.1% respectively and good agreement with M-HPp – D-HPp of 59.6%.

STATISTICAL ANALYSIS

Excel (Microsoft, Redmond, Washington, USA) was used to assemble the data. Means and standard deviations of the each variable in E analysis in all the three groups were calculated. SPSS 17 (Chicago) was used for statistical analysis. The one-way analysis of variance (ANOVA) was used to determine whether there was a significant difference among the mean values of the variables in the three skeletal pattern groups. A p-value < 0.001 was considered to be significant.

Unpaired t-test was used to determine whether there was a significant difference between the two sexes. Receiver operating characteristic (ROC) curves were done to examine the sensitivity and specificity of the E analysis variables to discriminate among the three skeletal pattern groups. Correlation coefficients were obtained for ANB angle, Wits appraisal, Beta angle and M-HPp – D-HPp to compare their relationship with each other.

RESULTS

The mean value for the E analysis variables in the originally selected skeletal Class I, II, III groups are listed in Table 1. The mean values for all the variables used in the study are listed in Table 2. The mean value for the effective length of maxillary base (M-HPp), the effective length of mandibular base (D-HPp) was 46.18 and 45.82 mm with a SD of 3.4 and 3.7 respectively. The mean value for sagittal dysplasia indicator (M-HPp – D-HPp) was 0.38 mm with a SD of 0.76, whereas the mean value for Class II and III skeletal pattern in the studied group were 8.86 mm and –5.64 mm respectively.

The ANOVA test showed that there were statistically significant differences between the three skeletal groups.
The unpaired t-test showed that there was no significant difference in the mean values of E analysis variables between males and females (Table 3).

Receiver operating characteristics curves revealed that sagittal dysplasia indicator (M-HPp–D-HPp) was best to differentiate skeletal Class I from Class II and III (Graphs 1 and 2). The value of M-HPp–D-HPp at 1.75 mm showed a 100% sensitivity and 92% specificity for discriminating a Class II group from a Class I group and the value of M-HPp – D-HPp at –1.5 mm showed 100% sensitivity and 95.7% specificity for discriminating a Class III group from a Class I group.

Correlation matrix for all the subjects is shown in Table 4 and Graph 3. On correlating the ANB angle, Wits appraisal, Beta angle and M-HPp minus D-HPp using Pearson’s correlation, there was excellent correlation in all the parameters. M-HPp – D-HPp correlates statistically significant with ANB angle, Wits appraisal and Beta angle with a Pearson’s correlation coefficient of 0.921, 0.943 and –0.911 respectively (Table 4). Beta angle correlates negatively with all the other parameters indicating that as Beta angle increases the other values decreases. Wits appraisal, ANB angle and M-HPp–D-HPp are positively correlating indicating that they have the same direction, i.e. as one increases the other also increases.

**DISCUSSION**

An accurate measurement of AP jaw relationships is an indispensable step in orthodontic treatment planning and is usually determined by cephalometric analysis. Various angular and linear measurements have been suggested to evaluate this relationship. According to Williams et al. and Jacobson, angular measurements are affected by changes in the jaw inclination, face height, and total jaw prognathism.

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Statistics/ mean squares</th>
<th>df2(Welch)/ F(ANOVA)</th>
<th>p-value</th>
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<td>M-HPp</td>
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<tr>
<td>Class I</td>
<td>25</td>
<td>0.38</td>
<td>0.7676</td>
<td>70.339</td>
<td>32.272</td>
<td>&lt;0.001*</td>
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*Significance: p < 0.001

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<th>N</th>
<th>Mean</th>
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<td>M-HPp–D-HPp</td>
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This study has introduced three new linear cephalometric variables to assess sagittal discrepancy, the effective length of maxillary base (M-HPp), the effective length of mandibular base (D-HPp) and sagittal dysplasia indicator (M-HPp – D-HPp). E analysis utilizes the skeletal landmarks, points M and points D to represent the maxilla and mandible, respectively. Unlike points A and B, these points are not directly affected by local remodeling due to dental movements. Points M and D also approximate to being centroid points similar to point S (Sella). As the center or the centroid of an area of an image indicates the mean point within a shape, about which it is subjected to least variation relative to non-mean anatomical points and therefore provides more stable reference points.

The reference plane used in our study is THL which is obtained through natural head position is another advantage associated with the E analysis. The other commonly used reference planes for assessing sagittal discrepancy are Frankfort horizontal plane and occlusal plane and the SN plane. All of these planes have been shown to have limitations.

Table 3: Comparison of male and female: unpaired t-test

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<tr>
<th>Sex</th>
<th>M-HPp</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>t</th>
<th>df</th>
<th>p-Value</th>
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<tbody>
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<td>0.957</td>
<td>23</td>
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<tr>
<td>Female</td>
<td>12</td>
<td>45.5</td>
<td>3.3643</td>
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</table>

| D-HPp | Male   | 13   | 46.5 | 3.6572 | 0.95 | 23  | 0.352  |
| Female | 12    | 45.083 | 3.7949 |     |    |      |

| M-HPp – D-HPp | Male   | 13   | 0.346 | 0.7183 | –0.225 | 23  | 0.824  |
| Female | 12    | 0.417 | 0.8483 |     |    |      |

Significance: p < 0.001

Graph 1: ROC curve analysis for the Class II prediction

Graph 2: ROC curve analysis for the Class III prediction

This study has introduced three new linear cephalometric variables to assess sagittal discrepancy, the effective length of maxillary base (M-HPp), the effective length of mandibular base (D-HPp) and sagittal dysplasia indicator (M-HPp – D-HPp). E analysis utilizes the skeletal landmarks, points M and points D to represent the maxilla and mandible, respectively. Unlike points A and B, these points are not directly affected by local remodeling due to dental movements. Points M and D also approximate to being centroid points similar to point S (Sella). As the center or the centroid of an area of an image indicates the mean point within a shape, about which it is subjected to least variation relative to non-mean anatomical points and therefore provides more stable reference points.

The reference plane used in our study is THL which is obtained through natural head position is another advantage associated with the E analysis. The other commonly used reference planes for assessing sagittal discrepancy are Frankfort horizontal plane and occlusal plane and the SN plane. All of these planes have been shown to have limitations. Natural head position has been shown to be highly reproducible and in our study, NHP was further...
A New Method for Assessment of Sagittal Dysplasia—E Analysis

The most commonly used parameter for assessing the sagittal discrepancy remains the ANB angle, but it is affected by various factors, such as the patient age, growth rotation of the jaws, vertical growth and the length of the cranial base, which can often be misleading.\(^5\)

To avoid these problems, the Wits appraisal was introduced.\(^5\) Though, it is not affected by jaw rotations, it can be affected by the inclination of the occlusal plane.\(^18\)

Recently introduced alternative, the Beta angle\(^20\) and W angle\(^21\) avoids the use of functional plane and is not affected by jaw rotations. Both these methods do not determine which jaw is prognathic or retrognathic while comparing Class II or III skeletal patterns.

E analysis was developed to overcome the limitations of the previously discussed parameters. This method does not depend on the unstable landmarks or the occlusal plane, as it uses two stable points—point M and D. The other added advantage of using the E analysis is that by comparing the effective length of maxillary base (M-HPp) and the effective length of mandibular base (D-HPp) from the norms, it can be deducted whether the maxilla or the mandible is responsible for the sagittal discrepancy. The investigation shows that mean value of M-HPp for skeletal Class I group was 46.18 mm with a SD of 3.4 and D-HPp was about 45.82 mm with an SD of 3.7 for Kerala population. Sagittal dysplasia indicator value (M-HPp – D-HPp) for skeletal Class I group was 0.38 with a SD of 0.76. There was no statistically significant difference between males and females. The receiver operating characteristic curves showed that cut-off point between Class I and II could be considered a sagittal dysplasia indicator (M-HPp – D-HPp) of approximately at 1.75 mm and between Class I and III at -1.5 mm.

The limitation of the study was that the subjects were selected only from Kerala (South India). As the cephalometric norms may vary with different population groups, the generalization of these findings is not possible. So, further studies are recommended in different population groups and investigation of its application.

E analysis can be used for assessing the true sagittal discrepancy in our practice. It can also be used for planning orthognathic surgery for patients with anteroposterior deformities, as it helps to distinguish between true skeletal Class I, II and III and also to locate the site of discrepancy (maxilla or mandible). Along with other parameters, E analysis enables better diagnosis and treatment planning.

**CONCLUSION**

From the study, we concluded that: E analysis has been put forward as a tool to assess the sagittal jaw dysplasia between the maxilla and mandible in an effort to overcome the limitations of the previously used parameters. The results of our study showed the mean values for the effective length of maxillary base (M-HPp) and the effective length of mandibular base (D-HPp) for skeletal Class I was 46.18 and 45.82 mm respectively.

For the skeletal Class I groups, sagittal dysplasia indicator (M-HPp – D-HPp) between 1 mm and -1 mm. For skeletal Class II, sagittal dysplasia indicator (M-HPp –
D-HPp) was greater than 1.75 mm and for skeletal Class II, sagittal dysplasia indicator (M-HPp – D-HPp) was beyond −1.5 mm. Based on these values a comparison between the M-HPp and D-HPp with the norms of skeletal Class I, E analysis can be used to assess which jaw was retrognathic or prognathic.

REFERENCES