An Assessment and Comparison of Pi Analysis with Other Sagittal Discrepancy Indicators

Abbas Sanjeliwala, Falguni Mehta, Renuka Patel, Amit Bhattacharya, Harshik Parekh, Rahul Trivedi

Abstract: Sagittal discrepancy is measuring antero-posterior relationship of the maxilla and mandible. It was one of the most common skeletal malocclusion for which patients seek orthodontic treatment and therefore an accurate evaluation of anteroposterior discrepancy is critical for orthodontic diagnosis. Various sagittal parameters have been used for assessment of sagittal discrepancy. Pi analysis was one of such parameters. Present study was carried out in Department of Orthodontia, GDCH Ahmedabad, for assessment and comparison of Pi analysis with other parameters. 120 pretreatment lateral cephalograms were traced and the values obtained were statistically analyzed. Result showed the mean values of Pi analysis for skeletal Cl I was 2.28±0.81 mm; for Cl II Div I was 8.60±0.89 mm; for Cl II Div 2 was 8.93±0.73 mm and for Cl III maloclusion was -2.65±1.40 mm and for Pi linear skeletal Cl I was 3.03±0.74 mm, for Cl II Div I was 9.63±0.72 mm, for Cl II Div 2 was 9.73±0.69 mm, for Cl III malocclusion was -2.65±1.50 mm. Result showed Pi analysis to be the most sensitive parameter among other parameters for assessing sagittal discrepancy.

Keywords: Sagittal discrepancy, Pi analysis, Yen angle, W angle, beta angle.

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I. Introduction

Sagittal discrepancy is measuring antero-posterior relationship of the maxilla and mandible. It is one of the most common skeletal malocclusion for which patients seek orthodontic treatment and therefore an accurate evaluation of anteroposterior discrepancy is critical for orthodontic diagnosis. Earlier the skeletal pattern was analyzed clinically by overall profile view of the patient and palpation of anterior surfaces of the basal part of the jaws with teeth in occlusion. After introduction of Cephalometrics by Broadbent in 1931, it has become an important diagnostic aid in Orthodontics. After Wylie’s first attempt to describe antero-posterior jaw relationship, various authors have evaluated, documented and established different values and norms for malocclusions in sagittal plane, few of which are Beta angle, Yen angle, W angle, APP-BPP, McNamara’s maxillomandibular differential. All these parameters are used to evaluate sagittal discrepancy. These parameters make use of points like point A, point B, condylion and sella to evaluate sagittal discrepancy. However, reliability of these parameters have been questioned as these parameters whether angular or linear may not give definitive picture of sagittal discrepancy as they may be affected by growth changes, changes due to tooth movement and variation due to ethnicity.

S. Kumar in 2012 introduced Pi analysis which uses point G and Point M, which are centroid point and hence considered stable, are projected on true horizontal line passing through point N (nasion). This true horizontal line is constructed perpendicular to true vertical obtained from radiographic image of true vertical metallic scale. True horizontal plane being extra cranial reference plane is independent of growth changes and highly reproducible. Point G and M are projected perpendicularly on true horizontal plane as G’ and M’ respectively. Internal angle between line GG’ and G’M is taken as Pi angle. The name is chosen because the angle resembles symbol Pi (α) in geometry. Linear distance between G’and M’ on true horizontal plane is taken Pi linear.

This study is carried out for assessment and accuracy of Pi analysis in various groups of malocclusion and its comparison with other sagittal discrepancy indicators.

II. Material And Methods

This study was carried out at the Department of Orthodontics and Dentofacial Orthopedics, Government Dental College and Hospital, Ahmedabad. Pretreatment lateral cephalometric radiographs of 120 subjects visiting Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, Ahmedabad in the age group of 16 to 25 years of age were taken as a sample for this study. Ethical clearance was obtained by institutional ethical committee. The criteria used for subject selection were:

- Should not have undergone orthodontic treatment previously.

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• Should not have any trauma to the face, TMJ disorders, congenital deformities, syndromes and craniofacial anomalies.
• Should not have missing or extracted or grossly carious teeth.

For the present study, cephalograms of 120 subjects were divided into four different types based on Angle’s classification of malocclusion, ANB angle and Wits appraisal.

<table>
<thead>
<tr>
<th>Skeletal Malocclusions</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANB angle</td>
<td>0-4°</td>
<td>&gt;4°</td>
<td>&lt;0°</td>
</tr>
<tr>
<td>Wits value</td>
<td>-3 mm</td>
<td>&gt;3 mm</td>
<td>&lt;1 mm</td>
</tr>
</tbody>
</table>

Cl II group was further divided into Cl II Div 1 and Cl II Div 2 respectively based on proclination of maxillary anterior teeth.

The lateral cephalograms were traced by a standard technique using 2H 0.5 lead pencil on acetate tracing paper by a single operator to minimize error.

True vertical line was drawn from radiographic image of a true vertical metallic scale and true horizontal was drawn perpendicular to the true vertical passing through Nasion (N).

Various reference points, planes and linear and angular parameters were drawn and recorded for evaluation as shown in figures.
III. Result

Data thus obtained was analysed using SPSS version 23. Tests performed were descriptive for scale data, one way anova with post hoc tukey test for intergroup comparisons. Pearson’s correlation and multiple regression analysis were done to estimate the best predictor for Pi analysis.

Graph 1: Mean value of various parameter

Graph 2: Sensitivity of Pi angle for different group

Graph 3: Sensitivity of Pi linear for different group
Various authors have proposed, both angular and linear variables in anatomical landmarks, growth, and facial morphology. The mean value of Pi angle for skeletal Class I is 60° ± 6.5°, for Class II Div 1 is 89.4° ± 8.9°, for Class II Div 2 is 67.6° ± 8.2°, and for Class III malocclusion is 81.3° ± 4.0°. The difference between these parameters is 65° ± 2.5°, for Yen angle is 4.6° ± 1.5°, and for W angle is 1.9° ± 1.3°.

<table>
<thead>
<tr>
<th>Group</th>
<th>Beta angle</th>
<th>Yen angle</th>
<th>W angle</th>
<th>Pi angle</th>
<th>M.M.D</th>
<th>App-BPP</th>
<th>YEN linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>R</td>
<td>.040</td>
<td>.128</td>
<td>.264</td>
<td>.575**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p value</td>
<td>.829</td>
<td>.484</td>
<td>.144</td>
<td>.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class II Div 1</td>
<td>R</td>
<td>.119</td>
<td>.336</td>
<td>.320</td>
<td>.784**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p value</td>
<td>.532</td>
<td>.069</td>
<td>.085</td>
<td>.006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class II Div 2</td>
<td>R</td>
<td>.095</td>
<td>.265</td>
<td>.220</td>
<td>.706**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p value</td>
<td>.625</td>
<td>.165</td>
<td>.231</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>R</td>
<td>.435*</td>
<td>-.390</td>
<td>-.255</td>
<td>.829**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p value</td>
<td>.038</td>
<td>.066</td>
<td>.240</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Correlation between Pi angle and other parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression coefficient R</th>
<th>Equation</th>
<th>R square</th>
<th>Std error of estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.M.D</td>
<td>.554*</td>
<td>18.17 - 0.694 * M.M.D</td>
<td>.307</td>
<td>3.940</td>
</tr>
<tr>
<td>Beta Angle</td>
<td>.888*</td>
<td>23.01 -0.654 * Beta angle</td>
<td>.789</td>
<td>2.176</td>
</tr>
<tr>
<td>W Angle</td>
<td>.676*</td>
<td>69.60 - 1.20 * W angle</td>
<td>.457</td>
<td>3.486</td>
</tr>
<tr>
<td>Yen Linear</td>
<td>.906*</td>
<td>(.508) + 2.5 * Yen Linear</td>
<td>.821</td>
<td>2.002</td>
</tr>
<tr>
<td>Yen Angle</td>
<td>.217*</td>
<td>15.59 -0.091 * Yen angular</td>
<td>.047</td>
<td>4.620</td>
</tr>
<tr>
<td>Pi Linear</td>
<td>.990*</td>
<td>(.303) + 0.939 * Pi Linear</td>
<td>.980</td>
<td>.671</td>
</tr>
</tbody>
</table>

Table 2: Correlation between Pi linear with other parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression coefficient R</th>
<th>Equation</th>
<th>R square</th>
<th>Std error of estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.M.D</td>
<td>0.562</td>
<td>19.98 -0.653 * M.M.D</td>
<td>0.315</td>
<td>4.16</td>
</tr>
<tr>
<td>Beta Angle</td>
<td>0.902</td>
<td>25.20 - 0.707 * Beta angle</td>
<td>0.814</td>
<td>2.17</td>
</tr>
<tr>
<td>W Angle</td>
<td>0.702</td>
<td>77.034 - 1.33 * W angle</td>
<td>0.493</td>
<td>3.58</td>
</tr>
<tr>
<td>Yen Linear</td>
<td>0.916</td>
<td>(.590) + 2.69 * Yen Linear</td>
<td>0.839</td>
<td>2.02</td>
</tr>
<tr>
<td>Yen Angle</td>
<td>0.257</td>
<td>19.17 -0.115 * Yen Angle</td>
<td>0.66</td>
<td>4.86</td>
</tr>
<tr>
<td>Pi angle</td>
<td>0.990*</td>
<td>0.433 + 1.04 * Pi angle</td>
<td>0.98</td>
<td>0.71</td>
</tr>
<tr>
<td>APP-BPP</td>
<td>0.711</td>
<td>27.03±1.8 * APP-BPP</td>
<td>0.431</td>
<td>1.349</td>
</tr>
</tbody>
</table>

Table 4: Regression estimation for best predictor of Pi angle.

IV. Discussion

Antero posterior discrepancy is one of the most common malocclusion for which patients seek orthodontic treatment. Sagittal relation can be determined from clinical observation to some degree, but are much more accurately evaluated from lateral radiographs. Various authors have proposed, both angular and linear variables to measure various malocclusion including sagittal jaw discrepancy. However, none of the parameter can be used universally as angular measurements can be erroneous due to changes in anatomical landmarks, growth, and facial morphology. Thus, a parameter which is independent of cranial reference plane or dental occlusion would be a desirable adjunct in determining true sagittal relation without being influenced by other factors. Pi analysis is one of such parameters.

Pi angle is measured by projecting point G (center of the largest circle placed at a tangent to the internal anterior, inferior, and posterior surface of mandibular symphysis) and point M (center of largest circle placed at a tangent to the anterior, palatal and superior surface of maxilla) on true horizontal line (line perpendicular to true vertical plane passing through N) as point G’ and point M’ respectively. Angle between line GG’ and G’M is taken as Pi angle. The mean value of Pi angle for skeletal CI I is 2.28 ± 0.813°, for CI II Div 1is 8.606 ± 0.894°, for CI II Div 2 is 8.933 ± 0.753° and for CI III malocclusion is 2.625 ± 1.402°.
them is statistically high significant (P<0.001). The values are in accordance with the study conducted by Kumar.S et al. who observed weak negative relation between Pi angle and Beta angle in all classes of malocclusion. Study of Jain et al observed statistically highly significant correlation between Pi angle and Beta angle (r=0.791). This difference observed may be because of variation in sample.

A statistically high significant correlation is found between Pi angle and Pi linear for skeletal Cl I (r=0.575) (p=0.001), for Cl II Div 1 (r=0.784) (p=0.001), for Cl II Div 2 (r=0.706) (p=0.000) and for Cl III malocclusion (r=0.829) (p=0.000). This is in accordance with the study of Kumar.S et al and Jain et al who observed statistically highly significant correlation between Pi angle and Pi linear (r=0.960) and (r=0.872) respectively.

Table 2 shows the correlation between Pi angle and other parameters. Negative correlation exists between Pi angle and Beta angle for skeletal Cl I (r=0.264) (p=0.144) and Cl II Div 1 (r=0.090) (p=0.636) and Cl II Div 2 (r=0.156) (p=0.410) and Cl III malocclusion (r=0.297) (p=0.169), however correlation is statistically not significant. This is in accordance with the study of Jain et al who observed statistically negative correlation between Pi angle and W angle (r=0.717) and between Pi linear and Yen angle for skeletal Cl I malocclusion (r=0.052) (p=0.777), for Cl II Div 1 (r=0.320) (P=0.084), for Cl II Div 2 (r=0.005) (p=0.980) and for skeletal Cl III malocclusion (r=0.327) (p=0.128) and negative correlation is observed between Pi linear and W angle for skeletal Cl I malocclusion (r=0.190) (p=0.296), for Cl II Div 1 (r=0.023) (p=0.904), for Cl II Div 2 (r=0.172) (p=0.363) and for Cl III malocclusion (r=0.393) (p=0.063). However this correlation is statistically not significant. This is in accordance with the study of Jain et al who observed statistically negative correlation between Pi linear and W angle (r=0.612) and between Pi linear and Yen angle (r=0.678).

Negative correlation exists between Pi linear and McNamara’s maxillomandibular differential (r=0.232) (p=0.202) for Cl I malocclusion. However, the correlation is statistically non-significant. A statistically significant negative correlation between Pi linear and McNamara’s maxillomandibular differential is observed for Cl III malocclusion (r=0.631) (p=0.001). This shows that as value of Pi linear increases, maxillomandibular differential value decreases. This may be due to projection of point M on true horizontal whereas Maxillomandibular differential is calculated by subtracting effective maxillary length from effective mandibular length.

Statistically significant negative correlation is observed between Pi linear and App-Bpp for skeletal Cl II Div 1 malocclusion (r=0.424) (p=0.019). Negative correlation is observed between Pi linear and App-Bpp

Graph 2 and 3 shows sensitivity value for Pi angle and Pi linear. Result shows Pi angle and Pi linear to be highly sensitive to truly determine skeletal malocclusion.
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for Cl II Div 2 malocclusion ($r=0.169$ (p=0.371) and Cl III malocclusion ($r=0.270$ (p=0.212). However, this correlation is statistically non-significant.

Negative correlation exists between Pi linear and Yen line for skeletal Cl I malocclusion ($r=0.089$ (p=0.777) and Cl II Div 2 ($r=-0.029$ (p=0.878). However, the correlation is statistically non-significant.

Table 3 shows regression coefficient for best predictor of Pi angle. Result shows Pi linear ($R^2=0.980$) to be the best predictor for Pi angle followed by Yen linear ($R^2=0.821$) and Beta angle ($R^2=0.789$). This is in accordance with the study of Kumar et al who observed best predictor of Pi angle was Pi linear ($R^2=0.92$).

Table 4 shows regression coefficient for best predictor of Pi linear. Result shows Pi angle to be the best predictor of Pi linear ($R^2=0.98$) followed by Yen linear ($R^2=0.839$) and Beta angle ($R^2=0.814$).

Thus, Pi analysis can be used for assessing sagittal discrepancy owing to its accuracy and reproducibility. However, fewer studies are available for Pi analysis so its findings should be further strengthened by correlating it with other sagittal discrepancy indicators.

Conclusion:

The following conclusions are drawn based on the findings of this study:

- Pi angle and Pi linear shows high significant difference to differentiate between skeletal Cl I, Cl II Div 1, Cl II Div 2 and Cl III malocclusion.

- On testing sensitivity and accuracy of Pi analysis
  Pi angle shows overall 84.35% sensitivity to discriminate between various groups of skeletal malocclusion.
  Pi linear shows overall 93.04% sensitivity to discriminate between various groups of skeletal malocclusion.
  Thus Pi analysis can be considered as highly sensitive parameter to discriminate between various groups of skeletal malocclusion.

- On correlating Pi angle with other sagittal discrepancy parameters
  Pi angle shows significant correlation with Pi linear in all groups of malocclusion.
  Pi angle shows negative correlation with Yen angle and W angle in skeletal Cl III malocclusion.

- On correlating Pi linear with other sagittal discrepancy parameters
  Pi linear shows significant negative correlation with McNamara’s maxillomandibular differential in skeletal Cl III malocclusion.
  Pi linear shows negative correlation with Beta angle, Yen angle and W angle.

- Regression estimation of Pi analysis
  Highest level of correlation is observed between Pi angle and Pi linear ($R^2=0.98$), so they are considered highly interchangeable in assessment of sagittal discrepancy.

Bibliography