# Cephalometric Analysis using a Template

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The purpose of this study is to introduce a template cephalometric analysis which is speedily but accurately performed. The introduction of yet another analysis when so many are available, however, bears some justification. A cephalometric analysis should ininclude initially some evaluation of the apical base relationship. If, during the course of a cephalometric evaluation, the apical base relationship proves deviant, then those factors which have contributed to the deviant relationship should be determined. This information not only aids in arriving at a diagnosis but also may influence the choice of treatment plan. Current methods of evaluating apical base relationship, however, do not necessarily reflect the true anteroposterior distance between A and B points.

The most widely used criterion of apical base relationship is the measurement of angle ANB.[1] Individuals displaying the same ANB measurement, however, may have widely differing anteroposterior distances between A and B points because of individual differences in the vertical distance between these two points. Furthermore, the value of angle ANB is dependent on the position of nasion which varies in an anteroposterior dimension among individuals.[2] A second method, the measured difference between A and B points projected on the natural or functional occlusal plane, is too dependent on the individual cant of the occlusal plane and its somewhat subjective location. Thus, small differences in occlusal plane location can result in higher or lower A-B values. An alternate and, perhaps, more accurate method of relating point A to point B is to measure the distance between A and B points projected on the sella-nasion plane.[3,4] This measurement, however, is influenced to a certain extent by the individual tilt of the sella-nasion plane.

Whichever method of determining the apical base relationship is used, there seems to be an element of disagreement concerning the characteristic facial morphology associated with extremes in the A-B apical base relationship. Previous studies have been concerned with the characteristic morphology associated with Class II, Division 1 retrognathic samples. Harris,[5] using a skeletal criterion of AB projected on the natural occlusal plane, and Hunter,[6] using angle ANB, found that in their Class II retrognathic samples the mandibles on the average were significantly shorter and more posteriorly positioned. Others[7,8] have suggested that anterior vertical facial dimensions influence the anteroposterior relationship of lower to upper jaw. Schudy[9] stressed this point even further and suggested that classification of facial types be based on angles of facial diversion, such as the mandibular plane-sella-nasion angle. Hunter,[6] on the other hand, found no significant differences in vertical dimensions between his orthognathic and retrognathic samples. He did, however, report a slightly greater average maxillary dentoalveolar height in the retrognathic group.

A recent multivariate factor analysis[4] revealed a "retrognathic" type factor which was characterized by a posterior mandibular position, a posterior maxillary position (to a lesser extent), a steep mandibular plane angle, and a short mandibular length. These results,

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however, were derived from mean figures; individual analysis would likely reveal one or more, or a combination of these characteristics contributing to a deviant A-B horizontal relationship.

Specifically, the purpose of this study is twofold: 1) To construct a diagnostic template based on a sample of 12 year-old boys which, when superimposed on a lateral cephalometric radiograph of a 12 year-old male, would indicate the apical base relationship without reference to a remote point or plane.

2) To use this template as a diagnostic aid to determine characteristic facial features and occlusions associated with extremes in the apical base relationship. These features, once determined, will at least indicate where to focus our attention when analysing subsequent cephalometric radiographs. If lateral cephalometric radiographs of 12 year-old males can indeed be rapidly diagnosed and assessed with the resulting template, then a complete sex and age specific atlas is proposed.

## Methods and Materials

### *Construction of the Template*

The subjects used in this study were from the twelve year-old control male sample of the Burlington Orthodontic Research Centre which represents a Canadian middle class population of European extraction.[10] Available for each subject were complete orthodontic records including lateral cephalometric radiographs and study models.

Tracings were made of each of the 126 radiographs and on each tracing eight landmarks were located (Fig. 1). Noted as well were: a measure of mandibular body length, gonion to B point (Go-B), the palato-occlusal angle (the angle formed by the palatal and functional occlusal planes and the Y intercept (intersection of the functional occlusal plane and the Y axis). Since

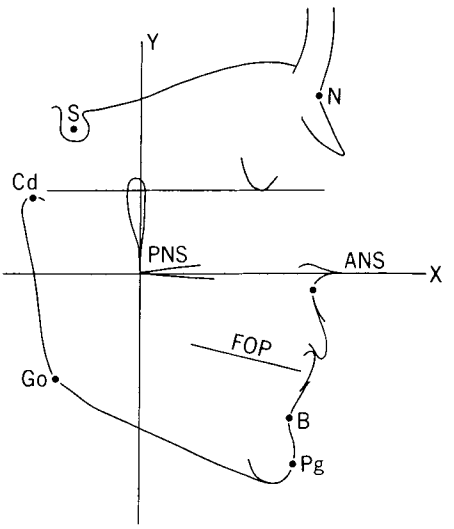


Fig. 1

PNS is sometimes difficult to locate accurately and consistently, this point was defined as the superimposition of the hard palate and the posterior wall of the maxilla.

Of initial interest is the anteroposterior relationship of mandible to maxilla. To determine this relationship the maxilla was stabilized by using the palatal plane as a horizontal reference axis (X axis). A perpendicular through PNS was selected as the vertical Y axis (Fig. 1). For each of the tracings the eight landmarks were assigned coordinates in relation to these axes. Means and standard deviations were then calculated for each of the seven coordinates, the palatal-occlusal angle and its Y intercept. The mean coordinates were transferred to an acetate sheet in relation to an X and Y axis. Additional points were plotted to indicate plus and minus one and two standard deviations from the mean. Grids were then constructed about each landmark to indicate plus and minus one and two standard deviations in both vertical and horizontal planes.

In addition, the mean position of the functional-occlusal plane was drawn in (located by the palato-occlusal angle and the Y intercept). Above and below the occlusal plane were located the positions representing plus one and minus one standard deviation from the mean functional occlusal plane position.

*Assessment of Factors Associated with Extremes in A-B Relationships*

Each of the 126 tracings which were used to construct the template was then re-assessed using the template. The A-B horizontal relationship, read in standard deviation units, was noted for each subject.

The sample was then divided into retrognathic, normal, and prognathic groups in the following manner: Those subjects that exhibited an A-B horizontal difference of at least *plus* one standard deviation or more were arbitrarily designated the prognathic group. Similarly, those subjects that exhibited an A-B horizontal difference of at least *minus* one standard deviation were arbitrarily designated the retrognathic group. The remainder, by default, fell into the "normal group." Of the 126 subjects, 23 were found to be retrognathic and 24 prognathic using these criteria.

The means of the seven coordinates, palato-occlusal angle, the Y intercept, mandibular body length (Go-B), and the A-B horizontal difference were calculated and then compared using the Student "t" test. The 47 subjects whose A-B relationships were deemed abnormal were further analysed in an effort to see which skeletofacial relationships and dimensions are coincidental with extremes in the apical base relationship.

Finally each individual in the prognathic and retrognathic group was reassessed noting in particular those features which were found to be significantly different. In this way the relative frequency of those dimensions which appear to influence the apical base relationship can be determined. At the same time the Angle classification was determined for each case and the relative frequency with which Class I (and normal), Class II, and Class III occlusions appear in both prognathic and retrognathic groups were noted as well.

## Results and Discusson

The means and standard deviations of the measurements utilized in this study are listed in Table I. The template derived from these means is illustrated in Figure 2. The template can be used to determine the horizontal relationship of B to A point in the following manner. A tracing of the radiograph to be assessed is marked off with a set of axes, horizontally through ANS-PNS, and vertically through PNS perpendicular to the palatal plane. The tracing is registered on the template and the horizontal difference between A and B points is read off in standard deviation units.

The mean facial polygons representing the retrognathic and prognathic groups are illustrated in Figure 3. The results of the "t" test are given in Table II. For 45 degrees of freedom, the "t" value for the 0.1 probability level is 2.69.

In descending order of "t" values, the retrognathic group differs significantly from the prognathic group in the following manner:

1. The chin is more posteriorly positioned (lower B-Y, Pg-Y values).

2. The length of the body of the mandible is smaller (smaller Go-B value).

3. The slope of the palato-occlusal plane is steeper (higher Pal-occ. angle).

4. The height of the anterior dentoalveolar unit is greater (higher B-X and

TABLE I

Statistical Description of
18 Cephalometric Measurements of 123 Males

| | Measurement (mm.) | Mean | S.D. | S.E. of Mean | Max. | Min. | Range |
|---|---|---|---|---|---|---|---|
| 1. | A-Y | 50.00 | 2.84 | 0.26 | 57.00 | 40.50 | 16.50 |
| 2. | A-X | 5.31 | 1.47 | 0.13 | 9.50 | 2.00 | 7.50 |
| 3. | B-Y | 43.80 | 4.01 | 0.36 | 53.50 | 33.50 | 20.00 |
| 4. | B-X | 41.57 | 3.55 | 0.32 | 51.50 | 34.50 | 17.00 |
| 5. | Pg-Y | 44.01 | 4.83 | 0.44 | 55.00 | 28.50 | 26.50 |
| 6. | Pg-X | 56.83 | 4.79 | 0.43 | 69.00 | 46.50 | 22.50 |
| 7. | N-Y | 51.72 | 4.03 | 0.36 | 63.00 | 40.50 | 22.50 |
| 8. | N-X | 52.25 | 2.95 | 0.27 | 62.00 | 45.50 | 16.50 |
| 9. | S-Y | 19.85 | 3.75 | 0.34 | 30.50 | 10.00 | 20.50 |
| 10. | S-X | 42.35 | 2.85 | 0.26 | 53.50 | 34.00 | 19.50 |
| 11. | Cd-Y | 31.45 | 3.75 | 0.34 | 40.50 | 21.50 | 19.00 |
| 12. | Cd-X | 22.67 | 3.79 | 0.34 | 32.50 | 13.00 | 19.50 |
| 13. | Go-Y | 25.39 | 3.26 | 0.29 | 33.00 | 18.50 | 14.50 |
| 14. | Go-X | 29.93 | 3.74 | 0.34 | 44.00 | 22.00 | 22.00 |
| 15. | Pal. -Occ. Angle | 13.21 | 4.47 | 0.40 | 30.00 | 2.00 | 28.00 |
| 16. | Y-Intercept | 16.54 | 2.61 | 0.24 | 26.00 | 9.50 | 16.50 |
| 17. | Go-B | 69.84 | 4.25 | 0.62 | 78.50 | 62.50 | 16.00 |
| 18. | A-B | 6.19 | 3.10 | 0.28 | 13.50 | -2.50 | 16.00 |

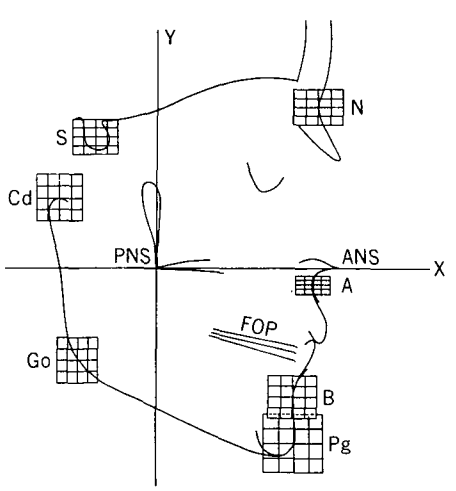


Fig. 2

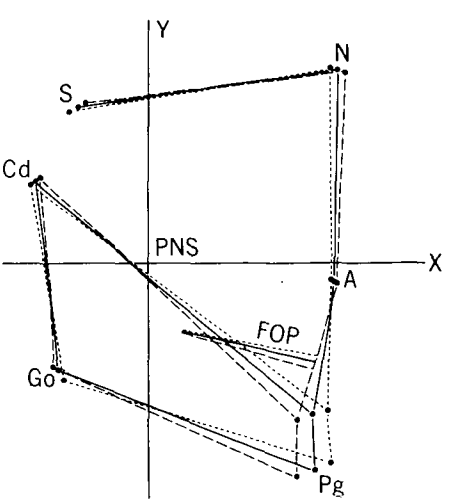


Fig. 3

TABLE II

Difference of Means Between
Retrognathic and Prognathic Groups

| | Measurement (mm.) | PROGNATHIC N = 23 Mean | S.D. | RETROGNATHIC N = 24 Mean | S.D. | "T" Value |
|---|---|---|---|---|---|---|
| 1. | A-Y | 49.65 | 3.04 | 50.12 | 2.97 | -0.53 |
| 2. | A-X | 4.37 | 1.46 | 5.56 | 1.23 | -3.04** |
| 3. | B-Y | 47.89 | 3.14 | 39.54 | 3.03 | 9.28** |
| 4. | B-X | 39.46 | 2.58 | 42.71 | 3.00 | -3.98** |
| 5. | Pg-Y | 49.02 | 3.65 | 38.92 | 4.28 | 8.67** |
| 6. | Pg-X | 54.26 | 4.17 | 57.90 | 4.56 | -2.85** |
| 7. | N-Y | 49.39 | 3.94 | 53.06 | 3.98 | -3.12** |
| 8. | N-X | 52.61 | 3.68 | 52.46 | 1.93 | 0.18 |
| 9. | S-Y | 22.24 | 4.20 | 18.33 | 3.81 | 3.34** |
| 10. | S-X | 41.24 | 2.44 | 43.04 | 3.56 | -2.02 |
| 11. | Cd-Y | 32.52 | 3.29 | 31.19 | 3.90 | 1.26 |
| 12. | Cd-X | 21.24 | 3.24 | 23.75 | 4.24 | -2.27* |
| 13. | Go-Y | 24.44 | 3.46 | 26.88 | 2.51 | -2.78* |
| 14. | Go-X | 31.85 | 4.43 | 28.25 | 3.49 | 3.01** |
| 15. | Pal. Occ. Angle | 9.85 | 3.87 | 15.67 | 4.31 | -4.87** |
| 16. | Y-Intercept | 17.59 | 2.79 | 16.06 | 1.74 | 2.23* |
| 17. | Go-B | 72.44 | 3.99 | 67.53 | 2.78 | 5.09** |
| 18. | A-B | 1.76 | 1.36 | 10.58 | 1.08 | -24.60** |

Degrees of freedom = 45

$*t_{95} = \pm 2.02$

$**t_{99} = \pm 2.69$

Pg-X values).

5. The anterior cranial base is more anteriorly positioned in relation to the maxilla (higher N-Y and lower S-Y values).

6. The gonial angle is lower and more posteriorly positioned (higher Go-Y, lower Go-X values).

7. The distance of A point from the palatal plane is higher (high A-X value).

The results of the "t" test and the polygon figures are misleading, however, when considered alone. Although significant differences were found between the two groups, they are comparisons of mean figures and do not necessarily apply to individuals.

Table III is a summary of the frequencies and relative frequencies with which each of the significant differences occurs between the retrognathic and prognathic groups. Unfortunately, lack of space prevents the publication of the complete table of the template assessment of each individual.* The complete table reveals that the two types differ in a more complex manner than the "t" test alone would indicate. Assuming that the significant differences between the two groups influence the A-B horizontal relationship, the results indicate that one or a combination of

*Interested investigators can secure the complete table of individual template assessments by writing to the author.

TABLE III

Summary of template assessment of individuals in the retrognathic and prognathic groups

| | Features Assessed | Possibilities | Retrognathic n 24 | | Prognathic n = 23 | |
|---|---|---|---|---|---|---|
| 1. | Angle classification | I | 9 | 37.5 | 16 | 69.6 |
| | | II | 14 | 58.3 | 5 | 21.7 |
| | | III | 1 | 4.2 | 2 | 8.7 |
| | | | 24 | 100% | 23 | 100% |
| 2. | Anteroposterior chin postion (B-Y relative to $\bar{x}$) | Anterior | 0 | 0.0 | 18 | 78.3 |
| | | Normal | 8 | 33.3 | 5 | 21.7 |
| | | Posterior | 16 | 66.7 | 0 | 0.0 |
| | | | 24 | 100% | 23 | 100% |
| 3. | Maxillary size and anteroposterior position (A-Y relative to $\bar{x}$) | Large | 10 | 41.7 | 7 | 30.5 |
| | | Normal | 4 | 16.7 | 5 | 21.7 |
| | | Small | 10 | 41.6 | 11 | 47.8 |
| | | | 24 | 100% | 23 | 100% |
| 4. | Mandibular body size (Go-B relative to $\bar{x}$) | Large | 2 | 8.3 | 15 | 65.2 |
| | | Normal | 5 | 20.9 | 4 | 17.4 |
| | | Small | 17 | 70.8 | 4 | 17.4 |
| | | | 24 | 100% | 23 | 100% |
| 5. | Mandibular body size relative to maxillary size (Go-B)-(A-Y) | Large | 3 | 12.5 | 14 | 60.9 |
| | | Same | 5 | 20.8 | 8 | 34.8 |
| | | Small | 16 | 66.7 | 1 | 4.3 |
| | | | 24 | 100% | 23 | 100% |
| 6. | Palato-occusal plane angle relative to $\bar{x}$ | Large | 12 | 50.0 | 1 | 4.3 |
| | | Normal | 11 | 45.8 | 8 | 34.8 |
| | | Small | 1 | 4.2 | 14 | 4.3 |
| | | | 24 | 100% | 23 | 100% |
| 7. | Dentoalveolar height (A-B vert. relative to $\bar{x}$) | Large | 17 | 70.8 | 3 | 13.0 |
| | | Normal | 5 | 20.8 | 10 | 43.5 |
| | | Small | 2 | 8.4 | 10 | 43.5 |
| | | | 24 | 100% | 23 | 100% |
| 8. | Maxillary position relative to nasion | Anterior | 7 | 29.2 | 13 | 56.5 |
| | | Normal | 4 | 16.7 | 7 | 30.5 |
| | | Posterior | 13 | 54.1 | 3 | 13.0 |
| | | | 24 | 100% | 23 | 100% |
| 9. | Anteroposterior position of gonial angle (Go-Y relative to $\bar{x}$) | Anterior | 3 | 12.5 | 15 | 65.2 |
| | | Normal | 7 | 29.2 | 2 | 8.7 |
| | | Posterior | 14 | 58.3 | 6 | 26.1 |
| | | | 24 | 100% | 23 | 100% |

factors may determine the horizontal relationship of A to B point. To pick out recurring patterns, however, is pointless because of the many combinations which may occur.

In addition to an assessment of apical base relationship, therefore, a cephalometric analysis using a template should include an assessment of: 1) mandibular body length relative to the standards and relative to maxillary length, 2) palato-occlusal plane angle, 3) anterior dentoalveolar height, 4) anteroposterior position of mandible and maxilla relative to the anterior cranial base, and 5) anteroposterior position of mandible relative to maxillary position.

The dental relationships in both groups proved to be very interesting. As one would expect, the majority of retrognathic individuals displays a Class II, Division 1 type of dental relation-

ship indicating that these types are likely predisposed to this type of malocclusion. There is, however, one youngster in the group with a Class III dental relationship. In this instance the mandible is larger than the maxilla yet this relationship is offset by a larger vertical dentoalveolar dimension and a more posteriorly positioned mandible. The net result is a retrognathic profile.

In the prognathic group the majority of cases was assessed as Class I or normal occlusions.

Only two boys of the prognathic group exhibited a Class III dental relationship while the majority had Class I or normal occlusions, and four cases exhibited a Class II, Division 1 dental relationship. These results indicate that any type of dental relationship can be superimposed on either a retrognathic or prognathic type face. An assessment of an individual's dental occlusion, therefore, does not automatically indicate the relationship of the skeletofacial parts. In the light of the preceding results, the proposed template could be used in the following manner.

*A-B Apical Base Relationship*

A tracing from the radiograph is placed on the appropriate template according to age and sex. The palatal plane is superimposed on the X axis and shifted until A point on the tracing coincides with the mean A point of the template. The position of B point on the tracing is simply noted in relation to the vertical components of the template grid for B point. The horizontal distance by which B point deviates from the mean is read directly in standard deviation units.

*Maxillary Length*

The palatal plane of the tracing is registered on the X axis of the template and the maxillary length (PNS to A point) is read in standard deviation units.

*Mandibular Body Length*

The tracing is placed on the template so gonion is superimposed on its appropriate horizontal and vertical means and B point is superimposed on its horizontal mean. The length of the mandibular body is read in standard deviation units. Similarly, total mandibular length can be assessed by using *condylion* in place of gonion.

*Mandibular Size Relative to Maxillary Size*

The lengths in standard deviations of the upper and lower jaws are compared to indicate whether maxillary and mandibular length are in harmony or not.

*Palato-Occlusal Plane Angle*

With the palatal plane registered on the X axis of the template, the slope of the angle can be compared to the norms on the template.

*Dentoalveolar Height*

With the palatal plane superimposed on the X axis, the tracing is shifted so A point coincides with the template horizontal A point mean, while keeping the palatal plane parallel to the X axis. The position of B point relative to its appropriate template grid is noted in standard deviation units.

*Relationship of Maxilla to Anterior Cranial Base*

With the palatal plane superimposed on the X axis, the vertical and horizontal positions of nasion and sella are noted in relation to their respective template grids.

*Gonial Angle Position*

With the palatal plane superimposed on the X axis, the vertical and horizontal positions of gonion are noted in relation to its template grid.

For those who are perhaps uncomfortable using the palatal plane as a reference plane, the anterior cranial base (sella-nasion) may be substituted. The tracing is merely superimposed on the

mean sella-nasion plane of the template and the various landmarks of the tracing are related to their respective grids.

## Summary and Conclusions

An atlas of age and sex specific cephalometric templates would provide a relatively simple yet accurate assessment of the apical base relationship and then reveal those factors which influence the relationship in each case. To demonstrate the usefulness of both of these procedures, a diagnostic template was constructed from the lateral tracings of 126 twelve year old boys. The template was then used to divide the sample into "prognathic" and "retrognathic" groups based on A-B values of at least plus or minus one standard deviation from the mean. This procedure was carried out to determine those skeletofacial dimensions or relationships which are characteristic of deviant apical base relationships.

Significant differences which distinguished the "retrognathic" from the "prognathic" group were: a more posteriorly positioned chin, a smaller mandible, a steeper palatal-occlusal plane angle, a greater anterior dentoalveolar height, and a more anteriorly positioned anterior cranial base in relation to the maxilla.

Individual assessments of the 126 individuals revealed that one or more of the above factors may contribute to "retrognathism" or "prognathism" in a complex or simple manner and any type of dental malocclusion may be superimposed on both these types although Class II, Division 1 malocclusions tended to be concentrated in the "retrognathic" group.

Due to the ease of performing a template cephalometric analysis, and the subsequent information which is speedily gained concerning skeletofacial dimensions and relationships which influence the apical base relationship, it is proposed that a full age and sex specific template analysis be compiled.

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