Dentofacial pattern and lower facial proportions

Balamani A.*; Kapoor D.N.**; Sharma V.P.***; Tandon P.****

A clear concept of dentofacial harmony, balance and association of anatomical entities are required for diagnosis, treatment planning and prognosis. The "cause and effect" relationship between anatomical entities are more clearly understood by analyses based on proportions rather than a single plane of reference. Facial proportions have a direct effect on dentofacial dysplasias and the lower part of the face contributes a lot to facial harmony and balance. Treatment modalities tend to improve or worsen the facial balance and most of it is portrayed in lower facial proportions. The present study evaluates the lower facial proportions, their individual components and their significance in different facial patterns; and determines sexual dimorphism, if any. 140 North Indian subjects in the age group of 14-20 years (70 males and 70 females) were selected and divided into a control group of Class I normal occlusion and a Class II division 1 malocclusion group. The malocclusion group was further segregated into hypo, hyper and normodivergent groups based on the SN MP angle (29±4°). Lateral head cephalograms of the subjects were traced and analysed. The measurements were subject to statistical analysis. It can be observed that angular parameters and skeletal proportions of the lower face effectively determine facial divergence. Dental parameters are less significant in determining facial divergence. Sexual dimorphism exists among the various groups of malocclusion and the difference was statistically significant.

Introduction

Deep beneath our understanding and high above our imagination lie the inner secrets of biological processes. Accurate diagnosis, treatment planning and prognosis involves a clear concept of dentofacial harmony, balance and association of anatomical entities. Analyses based on proportions establish the "cause and effect" relationship between anatomical entities. Dentofacial dysplasias could be projected on different parts of the face and the facial complex as a whole should be considered in all aspects for the best clinical judgement. Facial proportions are a more useful parameter in evaluating a cephalometric picture of long, short or average faces. Facial type and the changes in facial harmony and balance due to various treatment modalities are projected mostly on the lower part of the face. Hence, the present study is attempted to –

• evaluate the lower facial proportions.
• study the involvement of lower facial components and their significance in different facial types.
• determine sexual dimorphism, if any.

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Material and Methods
This study was conducted on lateral head cephalograms of 140 subjects, consisting of 70 males and 70 females, in the age group of 14-20 years. The subjects were divided into a control group of Class I normal occlusion and a Class II div. I malocclusion group. The malocclusion group was further divided into normodivergent, hypodivergent and hyperdivergent groups, based on the SN MP angle (29±4° IOS NORMS). None of the individuals had any prior orthodontic treatment.

Criteria for Selection: Control Group
- Presence of all permanent teeth (except III molars).

Grouping of Subjects

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<th>Hypodivergent</th>
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Table I

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Method
Individuals were positioned on a universal counterbalancing cephalostat with the FHP parallel to the floor and teeth in centric occlusion. KODAK X-ray films of 8" x 10" size were exposed at 70 KVP, 30 mA from a fixed distance of 60 inches for 2 seconds. The technique was standard, employed in the Department of Orthodontics, Faculty of Dental Sciences, KGMC, Lucknow.

The lateral head cephalograms were traced on acetate tracing sheets of 0.5 μ thickness, with a sharp 4H pencil using transilluminated light in a dark room. Measurements were recorded, nearest to 0.5 mm and 0.5°.

The various parameters used for study are as follows:

Cephalometric Points² (Fig. 1)
- Sella-Midpoint of hypophyseal fossa, a constructed point.
- Nasion-The anterior most point of the frontonasal suture in the median plane.
- Orbitale-Lowermost point of orbital fossa.
- "Machine Porion"-Marker extending into external auditory meatus and located as porion.
- Condylion-Most superior point on the head of the condyle.
- Articulare-Point of intersection of posterior
Fig. 1: Cephalometric Points used in Analysis

1. S - Sella
2. N - Nasion
3. Or - Orbitale
4. Po - Pochion
5. Cd - Condylion
6. Ar - Articulare
7. ANS - Articulare
8. PNS - Posterior Nasal Spine
9. Xi - Center of ramus
10. Go - Gonion - constructed and bisected
11. Me - Menton
12. Pm - Suprapogonion
13. A - Subspinale
14. B - Supramentale
15. UMT - Upper Molar Cusp Tip
16. UIE - Upper Incisor Edge
17. LMT - Lower Molar Cusp Tip
18. LIE - Lower Incisor Edge

Point A: Subspinale - The deepest midline point between anterior nasal spine and prosthion.
Point B: Supramentale - Most posterior point in the outer contour of mandibular alveolar process in the median plane.
UMT: Upper molar cusp tip (Biggerstaff et al., 1977).
UIE: Incisal edge of maxillary incisor.
LMT: Lower molar cusp tip (Biggerstaff, 1977).
LIE: Incisal edge of mandibular incisor

Cephalometric Planes (Fig. 2)
1. Sella-Nasion Plane
2. Frankfort Horizontal Plane
3. Palatal Plane
4. Occlusal Plane
5. Mandibular Plane.

Fig. 2: Cephalometric Planes used in the Analysis

1. SN Plane
2. Frankfort Horizontal Plane
3. Palatal Plane
4. Occlusal Plane
5. Mandibular Plane

Angular Parameters (Fig. 3)
1. SN-MP - Angle formed by sella-nasion plane and mandibular plane.
2. FMA - Frankfort mandibular plane angle.
3. PP-MP - Angle formed by palatal plane and mandibular plane.
4. OP-MP - Angle formed by occlusal plane and mandibular plane.
5. Gonial Angle - Angle formed by length of ramus and mandibular base (Ar-Go-Me).

margin of ascending ramus and outer margin of cranial base.
PNS: Posterior Nasal Spine - Constructed, the intersection of a continuation of anterior wall of pterygopalatine fossa and floor of nose. Marks the dorsal limit of maxilla.
Xi: The geometric centre of ramus of mandible (Rickets, 1979) (a constructed point).
Go: Constructed Gonion - The intersection of tangents of ascending ramus, posterior margin and mandibular base.
Me: Menton - Most caudal point in the outline of symphysis.
Pm: Suprapogonion - Point selected at the anterior border of symphysis between point B and pogonion where the curvature changes from concave to convex.
6. Angle of ramus inclination - The deviation of the ramus plane from vertical (90°) relation to the Frankfort plane was referred to as angle of ramus inclination, representing the inclination of posterior border of ramus.

**Fig. 3: Angular Variables used in the Analysis**

1. SN-MP Angle
2. FMA Angle
3. PP-MP Angle
4. OP-MP Angle
5. Gonial Angle
6. Ramus Inclination Angle

**Proportions (Fig. 4)**

1. LPFH:LAFH - Lower posterior facial height to lower anterior facial height.
2. UMT-PP:UIE-PP - Upper molar cusp tip to palatal plane to upper incisor edge to palatal plane.
3. LMT-MP:LIE-MP - Lower molar cusp tip to mandibular plane to lower incisor edge to mandibular plane.
4. Cd-Xi:Xi-Pm - Condylar axis to corpus axis.
5. Ar-Go:Go-Me - Ramal height to mandibular base length.
6. PP-OP:OP-MP - Distance from occlusal plane to palatal plane and occlusal plane to mandibular plane anteriorly.

**Linear Parameters**

1. PFH:LAFH - Lower anterior facial height.
2. LPFH (Ar-Go) - Lower posterior facial height.
3. UMT-PP - Distance from upper molar cusp tip to palatal plane (Biggerstaff et al., 1977).
4. UIE-PP - Distance from upper incisor tip/edge to palatal plane (Biggerstaff et al., 1977).
5. LMT-MP - Distance from lower molar cusp tip to mandibular plane (Biggerstaff et al., 1977).
6. LIE-MP - Distance from lower incisor tip/edge to mandibular plane (Biggerstaff et al., 1977).
7. Ar-Go - Height of ascending ramus.
9. Cd-Xi - Condylar axis-condylion to geometric center of ramus of mandible.
10. Xi-Pm - Corpus axis-Geometric center of ramus of mandible to suprapogonion.
Statistical Analysis

Error of Measurement

Ten cephalograms were selected at random, traced and analysed by the same observer, to evaluate the reliability and reproducibility of landmarks and measurement. Minimal error indicated that these measurements were reliable.

Mean and standard deviation of each parameter was calculated for all the groups and subjected to student’s 't' test to calculate the equality of two means and for comparison of parameters between and within groups. The results were tabulated (Table II-VII).

Discussion

Diagnosis and treatment of malocclusion depend upon the form and growth of human face. The interplay of vertical growth as related to anteroposterior growth is responsible for various facial types and there is a close interdependence of facial types with facial proportions. The various descriptions of facial structures such as open bite, deep bite, hypodivergent, hyperdivergent etc., (Schudy 1964) are related to structural variations predominantly below the palatal bone (Beckmann 1988).

The age group of 14-20 years represented a stable period where the influence of growth is less and the permanent dentition present are beyond the variability seen during the period of mixed dentition (Altemus 1960).

Changes in mandibular morphology were surveyed according to sex and it is well established that the female mandible of all races have a wider gonial angle, but smaller in dimensions. The mandible, being an important component of the lower face, needs to be segregated according to sex to maintain a homogeneous sample (Jensen and Palling 1954).

The Standard Base Line used here was the Sella-Nasion plane, to relate the cant of mandibular plane in classifying the control and malocclusion groups. The linear variables, angular variables and proportions were selected as related to lower facial proportions.

Control Vs Normodivergent Group

Among the angular parameters evaluated, the angle SN-MP, which determined the warpage or malformation of the mandible itself and the surface with which it articulates (Steiner 1953), and which is also considered as a direct measure of facial divergence (Schudy 1964), varied significantly among control and normodivergent groups. The Frankfort mandibular plane angle too differed among both the groups. The occlusomandibular plane angle, (OP-MP) which indicated a measure of the gonial angle, ramal height and level of mandibular molars situated within the corpus of the mandible (Schudy 1964) was significant among both the groups and so were the ramal inclination angle (Coben 1955), gonial angle and palatomandibular angle (Nahoum 1971).

A possible explanation for this significance could be the difference in dentoalveolar relationships between control and malocclusion groups. Significant differences were also established in lower posterior facial height (LPFH); lower anterior facial height (LAFH); upper molar to palatal plane (UMT-PP); upper incisor to palatal plane (UIE-PP); mandibular component of LAFH (PP-MP); and the parameters of mandibular morphology (Cd-Xi; Xi-Pm; Ar-Go; Go-Me). Lesser values were observed in the normodivergent group, which differentiated Class I and II malocclusions.

Table II: Mean-Angular Variables

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* Significant (p <0.05, <0.01)
  ** Highly significant (p= <0.001)
### Table III: Mean-Proportions

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* Significant (p<0.05, <0.01)
** Highly significant (p<0.001)

### Table IV: Mean-Linear Variables

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* Significant (p<0.05, <0.01)
** Highly significant (p<0.001)

### Table V: Angular Variables

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* Significant (p<0.05, <0.01)
** Highly Significant (p<0.001)
Comparison Between Groups

### Table VI: Linear Variables

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<td>0.35 0.84</td>
<td>1.76 1.82</td>
<td>1.85 0.41</td>
<td>2.04 0.82</td>
<td>1.23 0.81</td>
<td>3.78 1.43</td>
</tr>
</tbody>
</table>

* Significant (p<.05, p<.01)
** Highly Significant (p<.001)

### Table VII: Proportions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control Normo</th>
<th>Control Hypo</th>
<th>Control Hyper</th>
<th>Normo Hyper</th>
<th>Normo Hypo</th>
<th>Hypo Hyper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>'t' M F</td>
<td>'t' M F</td>
<td>'t' M F</td>
<td>'t' M F</td>
<td>'t' M F</td>
<td>'t' M F</td>
</tr>
<tr>
<td>LPHF:LAFH</td>
<td>3.35 2.88</td>
<td>4.39 8.94</td>
<td>3.58 8.08</td>
<td>6.33 7.59</td>
<td>1.47 6.79</td>
<td>6.07 10.64</td>
</tr>
<tr>
<td>UMT-PP:UIE-PP</td>
<td>0.12 5.59</td>
<td>3.37 2.44</td>
<td>1.65 4.53</td>
<td>1.67 0.62</td>
<td>2.84 4.08</td>
<td>4.81 3.64</td>
</tr>
<tr>
<td>LMT-MP:UIE-MP</td>
<td>1.32 5.29</td>
<td>0.71 3.25</td>
<td>4.36 5.11</td>
<td>2.95 0.20</td>
<td>0.40 1.51</td>
<td>2.80 1.58</td>
</tr>
<tr>
<td>Cd-Xi-Pm</td>
<td>3.35 6.34</td>
<td>4.51 9.51</td>
<td>1.85 7.09</td>
<td>1.70 0.82</td>
<td>1.05 1.32</td>
<td>3.0 2.49</td>
</tr>
<tr>
<td>Ar-Go-Go-Me</td>
<td>2.08 0.27</td>
<td>1.99 4.28</td>
<td>0.42 0.77</td>
<td>1.32 0.61</td>
<td>0.03 2.19</td>
<td>1.24 2.62</td>
</tr>
<tr>
<td>PP-OP-OP-MP</td>
<td>3.45 4.42</td>
<td>5.27 4.02</td>
<td>1.01 0.60</td>
<td>2.56 2.36</td>
<td>0.85 0.60</td>
<td>3.78 1.96</td>
</tr>
</tbody>
</table>

* Significant (p<.05, p<.01)
** Highly Significant (p<.001)

The ratio of LPFH:FAFH was within the range established by Horn in 1992. The ratio of upper posterior dental height to upper anterior dental height; lower posterior dental height to lower anterior dental height and the proportions of mandibular morphology were found to be significant. The values were lesser in females than males exhibiting sexual dimorphism (Jensen and Palling 1954).

**Hypodivergent Group of CI II Malocclusions**

Angular variables were lesser than the control group. The ramal inclination angle was increased as compared to the normodivergent group, but lesser than the control group, indicating the contribution of the angle to LPFH (Coben 1955). This also explained the forward rotation of the mandible in hypodivergence. The palatomandibular angle and the occlusomandibular angle were lesser than control (Beckmann 1988; Fields 1981; Schendel 1976; Schudy 1964).

The linear parameters, on evaluation, showed a significant increase in lower posterior facial height and decrease in anterior facial height, indicating a lengthening of ramus in hypodivergent group (Horn...
The proportions of lower facial height and mandibular morphology increased, signifying lengthening of ramus and corpus, thus contributing a skeletal change with deep bite in hypodivergence (Schudy 1964; Horn 1992; Beckmann 1988; Opdebeck and Bell 1978). Values were also found to be lesser in females.

**Hyperdivergent Group of CI II Malocclusions**

The angular variables were greater than in the control group. The ramal inclination angle was lesser, indicating a short ramus and backward rotation of mandible. The lower posterior facial height decreased and lower anterior facial height increased. No significant changes were observed in upper anterior and posterior dental height. Mandibular morphology was deficient signifying the hyperdivergent skeletal pattern (Schudy 1964).

The lower facial proportions were found to be decreased in hyperdivergence (Horn 1992; Vaden 1994; Biggerstaff 1977). Angular variables were slightly higher in females and the ratio of ramal length to corpus length was higher than the controls, in males, exhibiting sexual dimorphism.

Therefore, the contribution of the mandibular growth to the growth of the face involves a study of growth of the mandibular ramus, body, absolute measurements of parts, the directional growth of structures which may determine the effectiveness of their contribution. No character or a combination of characters field on infallible formula to the growth potential of the individual face.

Margolis (1953) had stated that a vertical discrepancy could occur due to arrest in vertical growth of rami/body of mandible; developmental deformity at the union of rami and body of mandibular and cranial base malformations. Variation in the growth pattern of the lower face, if could be recognised earlier would be helpful in predicting growth tendencies. There is always a difference in the ability of the alveolar bone to compensate for variations in growth patterns of upper and lower facial skeleton (Scott 1958).

Even though the increase in the posterior facial height had two components, lowering of the middle cranial fossa relative to the anterior, the condylar fossa being lowered, and an increase in ramal height (Karlsen 1997), only the ramal height differences could be predicted by this study. Further study could be done by relating the lower facial proportions to the cranial base, correlating angular variables to proportions and establishing the individual factors responsible for each facial pattern. Including subjects of Class III malocclusion and a study with totally homogeneous samples could be further aimed at.

Proportions could be clinically utilised as a diagnostic aid in assessing vertical malocclusions and facial pattern. They could also be helpful in assessing the prognosis of a case under treatment, so that cautious mechanics may be employed when dealing with complicated vertical malocclusions.

**Conclusions**

From this study of lower facial proportions, it was concluded that-

1. All the angular parameters related to lower facial proportions were good indicators of facial divergence.
2. The linear parameters and proportions of lower facial height and mandibular morphology determined facial divergence, but the upper and lower anterior and posterior dental height and proportions were less involved in determining facial divergence.
3. Sexual dimorphism existed among all the parameters especially among the proportions and the hyperdivergent pattern was slightly exaggerated in females which was directly related to mandibular morphology.

**References**

1. A Hand book of Cephalometric norms for Indian Ethnic Groups-Edited by Dr. K. Jothindra Kumar, Published by IOS.

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