CLASSIFICATION AND DIAGNOSIS.

DIAGNOSIS

Diagnosis is the determination of the nature of a disease. Although dento-facial deformities are not necessarily themselves diseases they may be the end result of disease. They are deviations from the accepted or normal physical growth pattern of the individual.

To recognise deviations, their nature and their extent we must have a concept of a normal or norm.

In the diagnosis of dento-facial anomalies, deviations from accepted norms are classified into various categories of malocclusion.

Certain workers in the field of orthodontia have given us their conception of the norm and their classifications of deviations from their norm.

ORTHODONTIC DIAGNOSIS

Diagnosis in orthodontics is concerned with

1. The recognition of deviations from a biometric norm.

2. Determination of the nature of a dento-facial deformity in relation to certain dental, facial cephalometric norms.

Lischar in defining diagnosis says

"Custom in orthodontic practice limits its use and it embraces

(a) The distinguishing of one form of malocclusion from another.

(b) The detection of anomalies of dentition and of the jaws, and related structures other than those of form and position.

(c) The degree of facial deformity associated therewith.

The characteristics of normal occlusion of the teeth, normal relation of the jaws one to another and together to the other bones of the skull and the proper relation of these dental and bony structures with the soft tissues investing
From such a multiplicity of factors and influences producing infinite variety it is not surprising that it took until 1899 and a man of the calibre of E. H. Angle (1) to attempt some scientific classification of these variations.

Angle pointed out the mandible and its teeth could assume only three possible positions in relation to the upper jaw and its teeth, normal, posterior and anterior. In 1906 Angle recognised the maxillary first molars as a fixed point from which deviation could be reckoned.

In 1907 Angle contended that the upper jaw was normal in size and position and that the lower jaw was underdeveloped and retruded in class II malocclusions. Although Angle has taken the maxillary first permanent molars as his point of reference he was careful to point out that tooth could vary in its position in the face in different types and races and it could also drift forward under certain conditions such as the loss of teeth anterior to it.

After almost 50 years Angle's classification is still universally used although in the light of modern research rather as a classification of the relation of the dental arches only and not as a criterion of jaw relationship, as Angle originally intended. Briefly as quoted by Brodie, Angle's classification is:

**Class I**
Arches in normal mesio-distal relations

**Class II**
Lower arch distal to normal in its relation to upper arch.

**Division 1.**
Bilaterally distal, protruding upper incisors. Primarily at least associated with mouth breathing.

**Subdivision.**
Unilaterally distal, protruding upper incisors. Primarily at least associated with mouth breathing.
Division II Bilaterally distal, retracted upper incisors normal breathers.
Subdivision Unilaterally distal, retracted upper incisors normal breathers.
Class III Lower arch mesial to normal in its relation to upper arch.
Division Bilaterally
Subdivision Unilaterally

Angle's classification although widely used was from its inception the centre of controversy and objection was raised to the selection of a single tooth as the basis of diagnosis. The first serious classification to gain any recognition since Angle's was that of Simon published in Germany in 1922 and translated by Lischner in 1926. Although discredited later, Simon made an attempt to relate the dental arches to the face and total head. He used anthropometry in his studies and although his findings were later found to be erroneous he seems to have been the first to broaden the scope of the study of malocclusion beyond the field of the jaws and teeth. Simon established a three plane system of reference and used the following planes which cut each other at right angles.

1. The median sagittal plane
2. The Frankfort horizontal plane
3. For the third plane, a plane was needed to measure in an antero-posterior direction. Since Simon wanted a denture relationship he selected the orbitale and constructed a plane passing vertically through this point and at right angles to the Frankfort Horizontal plane.

A prominent part of Simon's diagnosis depended on the relation of the orbital plane to the tips of the cusps of the upper canines.

Simon claimed after measuring large numbers of German children with normal occlusion that in normal occlusion the orbital plane was found to pass through the tip of the cusp of the maxillary canine in a large majority of the cases regardless of the age of the patient.
With this relationship as a starting point Simon made his classifications.
If the canines were lying anterior to the orbitale plane the arch was said to be in protraction and if posterior to the plane the arch was in retraction.
The mandibular arch as in the Angle classification was then analysed on the basis of occlusions.
By means of a most elaborate articulation device Simon related his plaster casts to his planes of reference. For this technique he coined the word gnathostatics but since the canine orbital law was soon disproved his system of gnathostatics never gained much popularity.

**DIAGNOSIS ACCORDING TO SIMON'S CLASSIFICATIONS**

A. Deviation from median sagittal plane
   1. Contractions
   2. Distractions
   3. Arch form and inclination of tooth axis are also determined from this plane.

B. Deviation from the Frankfort horizontal plane.
   1. Abstractions
   2. Attractions
   3. Angle between the Frankfort horizontal and the occlusal plane.

C. Deviations from the Orbital plane
   1. Protractions
   2. Retractions
   3. Sagittal symmetry and inclination of the axis of the teeth are also determined from the plane.

Simon also lists seven combinations of deviation of the dental arches in relation to the orbital plane.
1. Both jaws in normal relation to each other.
2. Upper jaw normal, lower jaw distal.
3. Upper jaw normal, lower jaw mesial.
4. Lower jaw normal, upper jaw mesial.
5. Lower jaw normal, upper jaw distal.
6. Upper jaw mesial, lower jaw distal.
7. Upper jaw distal, lower jaw mesial.

Broadbent after a study of 75 white skulls showing no evidence of mutilation or malocclusion disproved Simon's theory of "The law of the canines."
The orbital plane fell distal to the canines in 91% of the cases and in none passed through the tip of the canine. In 4% of the cases the orbital plane passes through the first permanent molar. Hellman in 1930 examined a series of American Indian skulls and discovered a general tendency for the orbital plane to come into a more posterior relation to the teeth as the face developed from infancy to adulthood.

Lischer modified Angle's classification somewhat and introduced the following terms,
Neutroclusion or Class I.
Distoclusion or Class II.
Mesoclusion or Class III.
He also defined four arch positions by the following:-
Buccoclusion,
Linguocclusion,
Supraclussion,
Infracclusion.
Fischer (2) uses the word symmetry with the meaning of balance and quotes the definition of symmetry as a correspondence in size, form, and arrangement of parts on opposite sides of a plane, line or point. Conversely the word asymmetry means imbalance.
Asymmetry of the component parts of the dento-facial complex may be unilateral or bilateral and may occur in the following directions.
1. Antero-posterior
2. Supero-inferior
3. Medio-lateral

Fischer stresses the individuality of each orthodontic case and appeals for the replacement of concepts based upon classifications or statistical norms by operational concepts.

Fischer quotes his "Trait concept of malocclusion" in which he postulates that all malocclusions seem to consist of various combinations of undesirable traits. Since these traits are independent of each other and show great variation we are confronted with an endless variety of combinations and each individual patient presents a new situation. Thus schematic methods of diagnosis must be replaced by case analysis applicable to the individual patient.

In his explanation of "Sectional treatment" the writer says that although there are innumerable combinations of factors involved in different malocclusions, some combinations resulting in a certain pattern repeat themselves often enough for the orthodontist to become experienced in treating them.

This experience must be applied to the movements of single teeth and groups of teeth toward the attainment of the objectives of treatment.

We owe a debt to Broadbent who opened a new era in orthodontics diagnosis with his adaption of the Western Reserve craniostat to the measurement of live subjects instead of dried skulls.

Registration of the internal features of the face and cranial base was solved through the perfection of standard X-ray procedure. The work of Broadbent, Brodie and others have been dealt with previously in respect of their work on growth and development.

Margolis (3) in 1947 using the cephalometric technique introduced his maxillo-facial triangle.
THE MAXILLO-FACIAL TRIANGLE

OBJECTIVES.

1. To appraise the proportional developmental level of the lower third of the face.

2. To describe a basic pattern in a balanced well developed face and to recognise deviations therefrom.

3. To orientate the dentition within the face.

4. To note growth subsequent to orthodontic treatment.

Angle admonished the profession to have "fixed in our minds the outline of a perfect face."
The famous skull "Old Glory" was credited by Angle with perfect occlusion but the dentition is prognathous compared with that of a modern white.

Tweed demonstrated that double protrusions have been created much too often as they are an end result easily produced with almost any appliance and sometimes with disastrous facial results.

Todd has emphasised that skulls of dead children are often defective and therefore not the best source of study of normal growth. It is equally true that most orthodontic patients have deformities comprising the bony parts of the lower third of the face as well as dental apparatus.

We must have some useable concept of normal basic facial pattern. Then we can appraise proportional deficiencies and abnormalities of growth and orient the dentition.

Margolis says term "perfect face" should be discarded because it has no scientific or clinical value. It means entirely different things to different people.

We must have criteria to evaluate the balanced, well developed face and to recognise poorly developed areas within the face which in turn affect occlusion.
CONSTRUCTION OF THE MAXILLO-FACIAL TRIANGLE

Standardised sagittal cephalic X-ray is the basic essential
Three sides are:-

1. Cranial base line  \( N - X \)
2. Facial Line  \( N - M \)
3. Mandibular line  \( M - X \)

1. Cranial line is established by the nasion and the
top of the occipito-sphenoidal suture and is continued
posteriorly to meet the mandibular line at \( X \).

2. Facial line is established by drawing a line from
nasion downward tangent to the mental eminence at \( M \) and
continued to meet the forward extension of the mandibular
line.

3. The mandibular line is tangent to the inferior
border of the mandible and is continued in both directions.

Three angles.

Cranio-facial at  \( N \)
Cranio-mandibular at  \( X \)
Facio-mandibular at  \( M \)
Margolis' first observations were on thirty Indian skulls selected on the basis of excellence in occlusion and development of the skull. Then 100 white American children between ages of six to nineteen were selected on the same basis. No separations were made as to the nationality, age or sex.

**OBSERVATIONS**

The characteristics of the maxilla facial triangle for the hundred children fell into a range sufficiently narrow to establish a basic pattern. This pattern for the non-prognathous, well developed face exhibited the following criteria.

1. At N
   Average 72.6 Deg. 92% readings 72.6 ± 3.4Deg.
2. At M
   " 67.7 "  85% " 67.7 ± 3.5 "
3. At X
   " 39.7 "  81% " 39.7 ± 3.5 "

4. The mandibular line when continued posteriorly touched the occipital bone posterior to foramen magnum or fell below it.

5. The facial line intersected the lingual surface of the crown of the mandibular incisor.

6. The mandibular incisor angle was 90 deg. ± 3 Deg.

**CORRELATIONS**
The smaller the angle at N, more receding the chin
Cranio-mandibular angle indicates deviations in vertical development and corresponds in its indications to the
Frankfort mandibular plane angle of Tweed. A large cranio-
mandibular angle may mean 1. A large gonial angle with open bite.


Margolis (4) constructs his maxillo-facial triangle from three planes and in a further study makes deductions from their orientations
A sample cephalographic tracing obtained from sagittal roentgen cephalogram indicating the maxillo-facial triangle and some other anatomical landmarks. These and others are readily available in a good cephalogram.

1. Long axis of maxillary incisor, bl, long axis of mandibular incisor.
2. Intersection of 1 with cranial base forming incisor-cranial base angle.
3. Cranial edge of sphenoid-occipital synchondrosis
4. Articulare (Bjork)
5. Base of occiput posterior to foramen magnum
6. Projection of occlusal surface of maxillary and mandibular first permanent molars.
7. Pogonion—anterior point on mental protuberance
8. Bolton point
9. Projection of gonion on mandibular line
10. Projection of mental protuberance (pogonion) on mandibular line
9-10, Length of body of mandible
11. Intersection of 1 with mandibular line forming the incisor mandibular angle

Maxillofacial Triangle (MFT)

<table>
<thead>
<tr>
<th>Sides:</th>
<th>Angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial base line</td>
<td>W (SO) X</td>
</tr>
<tr>
<td>Facial line</td>
<td>W (W') M</td>
</tr>
<tr>
<td>Cranial base line</td>
<td>W</td>
</tr>
</tbody>
</table>
THE PRINCIPLE OF THE MANDIBULAR PLANE.

In the balanced well developed skull, mandibular line of the MPT when continued posteriorly either is tangent to the occipital bone posterior to foramen magnum, or falls below the base of the occiput.

When the mandibular plane, extended posteriorly enters the cranial vault it indicates a vertical development discrepancy due to any one or combination of the following.

1. Arrest in vertical growth of the ramus and/or body of the mandible.

2. Development deformity at the union of the rami and the body of the mandible.

3. Cranial base malformation causing inadequate downward growth of the mandibular fossa with resultant higher temporo-mandibular articulations.

It is erroneous to single out a single criterion on which to base diagnosis, for instance the incisor mandibular angle. The incisor mandibular angle must be correlated with the level of cranio-facial skeleton development and dento-cranio-facial orientation.

DENTO-CRANIO-FACIAL ORIENTATION.

Having determined the pattern of the cranio-facial skeleton it is then necessary to relate the dentition to this skeletal pattern. Margolis postulates that when the maxillo-facial triangle is within the normal range, then in the orthognathous profile the facial line intersects the lingual surface of the crown of the mandibular central incisors or lies anterior to these teeth. The long axis of the mandibular incisor is then perpendicular to the mandibular plane.

When the cranio-facial pattern is normal and the denture is anterior to the facial line, Margolis describes the profile as prognathous. Margolis differentiates between the terms prognathous and protrusion. Prognathous involves a forward positioning of not only the teeth and supporting alveolar bone but also the basal bone of the maxilla or mandible or both in cases of bimaxillary prognathism.
Bimaxillary protrusions or single protrusions are commonly the result of orthodontic treatment when arches have been extended and teeth, and to a certain extent, alveolar bone is anterior to the basal supporting bone. These are malocclusions, whereas prognathism may be well within the normal especially for certain races.

In addition to the information gained from this study of the cranio-facial skeletal pattern and the dento-cranio-facial pattern much information may also be gained from the examinations of the relation of the teeth to their fellows in the same arch and their occlusions with teeth of the opposing arch.

This description of the uses of the maxillo-facial triangle is a resurrection and continuation of the original work of 1947. While the application of this form of analysis of malocclusion and skeletal malrelation is interesting and in 1947 was of much value, at the present time I consider Down's or Graber's analysis more thorough and more productive of data to assist in case analysis.

The most comprehensive cephalometric appraisal for diagnosis and prognosis is the Down's (5) analysis of 1948 which is based upon a facial pattern representing a mean or average form for individuals with excellent occlusions. The control material for Down's study consisted of twenty living individuals with ages varying from twelve to seventeen years and equally divided as to sex. All possessed clinically excellent occlusions. Models, photographs cephalometric and intra-oral X-rays were taken. Tracings were made of all lateral head X-rays and the Bolton triangle and registration point outlined on each tracing. For the study the head was divided into cranium and face with the face further divided into

1. The upper face
2. Teeth and alveolar area
3. Lower face or mandible
1. The skeletal pattern - serial pictures are superimposed at R with the Bolton planes parallel.
2. A diagrammatic break down of the areas of the head.

Two objectives of study

1. To appraise the pattern of the facial skeleton, exclusive of the teeth and alveolar process
2. To appraise the relationship of the teeth and alveolar process to the facial skeleton.

The skeletal pattern.
Maximal average (mean) and minimal values for
1. Facial angle. 2. Angle of convexity. 3. A - B Plane to the facial plane. The last is an expression of the antero-posterior relationship of the mandibular denture base to the maxillary denture base.

Maximal, average (mean) and minimal values for
1. mandibular plane angle and 2. Y axis angle.

The relationship of the denture to the skeletal pattern.
Maximal average (mean) and minimal values for 1. cant of occlusal plane, and 2. axial inclination of the upper to the lower incisor.

Maximal, average (mean) and minimal values for 1. relation of the lower incisor to the mandibular plane, and 2. the distance in mm. from the incisal edge of the upper central to the plane A - P.

The form of the mandible at the symphysis and the relationship of the incisor teeth to the facial plane in the 20 cases studied. They are arranged in the increasing magnitude of the facial angle. The first figure is reproduced at the end.
OBSERVATIONS

1. Skeletal pattern in norma-laterals

The skeleton pattern of the face is determined by the maxillary bones and mandible these will be considered first. FACIAL ANGLE is an expression of degree of recession or protrusion of the chin.

ANGLE OF CONVEXITY is a measure of protrusion of the maxillary part of the face to the entire profile.

AB ANGLE - In relation to the facial plane is a measure of the relation of the anterior limits of the denture bases to each other and to the profile.

MANDIBULAR PLANE ANGLE - is a measure between the Frankfort plane and extension of the tangent to the lower border of the mandible.

Y-AXIS - A line from the sella turcica to gnathion is called the Y-axis. All these lines and planes except the AB Plane are related to the reference plane the Frankfort horizontal.

<table>
<thead>
<tr>
<th>Facial angle</th>
<th>82 to 95 mean</th>
<th>87.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle of convexity</td>
<td>+10 to -85</td>
<td>0</td>
</tr>
<tr>
<td>AB Plane to Facial Plane</td>
<td>-9 to 0</td>
<td>-4.6</td>
</tr>
</tbody>
</table>
Mandibular Plane Angle to Y-Axis, Frankfort Plane
28 to 17 Mean 21.9
66 to 53 " 59.4

Downs says "within these ranges one can expect to treat a malocclusion to a well balanced face provided one maintains a balanced relationship of the denture to the skeletal pattern. Excessive deviations of any of these relationships may be considered as unfavourable variations which reduce the prospect of obtaining an harmoniously balanced face in direct ratio to the amount of deviation."

2. **AREA OF TEETH AND ALVEOLAR PROCESS.**

**RELATIONSHIPS**

Cant of the occlusal plane. Occlusal plane was related to the Frankfort plane.

Axial inclination of upper and lower incisors.

Axial inclination of mandibular incisor to mandibular plane.

Protrusion of maxillary incisors.

Axial inclination of lower incisors to occlusal plane.

Ranges and means for above relationships are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Minimal</th>
<th>Maximal</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cant of occlusal plane</td>
<td>+1.5</td>
<td>+14</td>
<td>+9.3</td>
</tr>
<tr>
<td>( \overline{1} ) to ( \overline{n} )</td>
<td>130</td>
<td>150.5</td>
<td>135.4</td>
</tr>
<tr>
<td>( \overline{n} ) to Mandibular plane</td>
<td>-6.5</td>
<td>+7</td>
<td>91.4</td>
</tr>
<tr>
<td>( \overline{n} ) to Occlusal plane</td>
<td>+3.5</td>
<td>+10</td>
<td>+14.5</td>
</tr>
<tr>
<td>Distance ( \overline{1} ) to facial Convexity plane AP</td>
<td>-1 mm</td>
<td>+5 mm</td>
<td>+2.7</td>
</tr>
</tbody>
</table>

Lateral views show wide variations in the relation of the components of the facial complex, however those patients with good occlusions seem to possess a sense of balance and harmony in their X-rays.

These standards especially when translated into figures establish a pattern from which we can measure deviations which are present in malocclusion.

Excessive disharmony of the skeletal pattern militates against success in treatment and an early recognition of these two factors by the Downs' analysis will forewarn the orthodontist of the limits of successful treatment.
The analysis of malocclusions compared with the standards will indicate where the deficiency of development lies or the areas of disharmony responsible for the malocclusion. Serial cephalometric analysis of treated cases provides proof of what has or has not been achieved in treatment and what effect growth and development has on the structures after treatment. Our present orthodontic appliances are shown to be incapable of restoring or maintaining balance and harmony of the component parts of the face without sacrificing dental units in many cases. Results of this study of 20 individuals may be summarised.

1. There is a facial pattern which represents mean or average form for individuals with excellent occlusions.
2. There is a noticeable deviation on each side of the mean findings which represent the usual variations one must expect.
3. Excessive deviations will be evident as disharmonies or imbalance of particular areas.
4. Skeletal pattern may be described in figures and the degree of deviation may be reliable guide in prognosis of treatment.
5. Relationship of the denture of any case to its skeletal pattern can be compared to that appertaining in cases of good relationship and harmony.
6. Serial study indicates changes due to treatment and also growth and development changes.

The work of Wendell L. Wylie(6) on antero-posterior dysplasia was published shortly after the Downs' analysis. Wylie emphasised the fact that dento-facial disturbances are problems in morphology that we are faced with considerable variety in size and form in the parts which make up the cranio-facial complex. In some cases it would appear as though these parts were flung together at random with consequent lack of balance and proportion.

He quotes a Class III relationship which may be due to an unfortunate combination of facial parts. The mandible outsize in one case may be perfectly normal on other skulls.
According to the work of Elsasser and Wylie each of the following factors when greater than average will predispose toward a Class II relationship.

1. Length of cranial base between glenoid fossa and tuberosity of maxilla.
2. Overall length of maxilla
3. Position of maxillary first permanent molar when measured forward from tuberosity.

Overall length of mandible when undersize predisposes to Class II relationship.

The following points were projected to the Frankfort horizontal plane.

1. Most posterior point on head of mandibular condyle
2. Centre of sella turcica
3. Pterygomaxillary fissure
4. Buccal groove of maxillary first permanent molar.
5. Anterior nasal spine.

These projections can be seen on the accompanying drawing and also the measurements made of the mandibular length.
Good facial balance is obtained if various dimensions were combined in the face as indicated in table below.

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenoid fossa to Sella</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Sella to Ptm</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Maxillary length</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Ptm to 6</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Mandibular length</td>
<td>103</td>
<td>101</td>
</tr>
</tbody>
</table>

The term dysplasia as used by Wylie is taken to denote the random combination of cranio-facial parts which in themselves are neither abnormally large or abnormally small but which when taken together produce an undesirable combination of parts.

These figures are not a normal but a mean value. They may be larger or smaller in proportion and pattern would remain the same or one measurement may be much larger or smaller provided that there is a compensating variation in another part in the appropriate direction.

This study by Wylie gives a method whereby discrepancies in the size of facial bones occurring in the antero-posterior plane of space may be assessed in terms of millimetres. The method of assessment indicates when compensation is not sufficient between varying parts, what form the dysplasia will take. It also permits the location of the dysplasia in one or more of five areas.

If there is no indication of dysplasia in this antero-posterior plane it is indicated, and we have to look elsewhere for the existing dysplasia, such as in the vertical dimensions.

Elsasser and Wylie (7) made a study of the cranio-facial morphology of mandibular retrusion for which they used orientated lateral head films of 48 females (ages 5 to 23) and 45 males ages (5 to 16) having clear cut Class II Division 1 malocclusions.

Following measurements were taken.
1. N - B Nasion-bolton
2. N - C Line N - B is divided by a projection to it from the head of the condyle. Anterior portion is designated N + C.
3. N - C Rest Position
4. Overall mandibular length
5. Go - Gn

**PROJECTIONS TO FRANKFORT HORIZONTAL PLANE**

C. Most posterior point in head of condyle
S. Centre sella turcica
PTm Pterygo-maxillary fissure
Gn Gnathion
1. Incisal edge of maxillary central incisor.
NS Anterior nasal spine

Distances are measured along Frankfort plane between these various points in different combinations. Angular measurements were also taken. These points, distances and angles can be seen in the tracings below.
CONCLUSION

Class II Division 1 malocclusion is the result of a dysplasia between the two jaws and no single part of the cranio-facial anatomy can be singled out as being the cause in every instance.

Antero-posterior discrepancy between the arches is approximately 7 mm or the width of an average premolar.

Analysis of individual data shows that factors of basic facial pattern interact with one another. Two variable may counteract or may reinforce one another.

Wylie and Elsasser make an important point, I think, when they say that although dimensions of underlying facial structures are continuous variables the occlusion of the teeth may be considered a discontinuous variable.

When the erupting teeth particularly the first permanent molars erupt into occlusion there is an interdigitation of cusps by which the opposing teeth tend to settle into one another in continued mastication.

The adjustments for this precise setting takes place in the alveolar process and temporomandibular joint.

Two individuals with practically the same cranio-facial make-up and measurements could easily fall into different occlusal relations and hence be classified according to Angle's classification as either Class I or Class II.

When the first permanent molars particularly, come into point to point relation the type of malocclusion may be decided in some cases, that is if we are only going to rely on occlusal relation for a classification.

This study found that the malocclusion investigated was basically different in males and females and the writers suggest that inheritance may play a part in the etiology.
Graber (8) gives an excellent paper on clinical cephalometrics and although his system is simpler than that of Downs his analysis is admirably suited for application in the orthodontic practice. These facts together with his advocacy of a simpler technique of head positioning leaves no excuse for the specialist in orthodontics not to make full use of this diagnostic aid.

Planes and landmarks.

In the analysis he divided the malocclusions into three groups.

1. Skeletal dysplasias
2. Dental dysplasias
3. Skeletal - dental dysplasias

1. **SKELETAL ANALYSIS**
   
   (a) Angle of facial convexity
   
   (b) Apical base relationship
Diagram of Freeman-Rasmussen method of relating maxillary and mandibular apical bases.

(c) Inclination of the mandibular plane

2. DENTURE ANALYSIS

Part which can be influenced by treatment

(a) Upper incisor axial inclination to N-S plane.
(b) Lower incisor to mandibular basal bone
(c) Relation of incisors to occlusal plane
(d) Relation of upper and lower incisors
(e) Relation of upper incisor to the facial N - P Plane.

Graber's analysis is particularly useful in Class II cases and he gives instances of the value of cephalometrics in deciding into which of the three groups the case can be classified. An accurate case analysis determines the success of treatment procedure and appliances used must be relegated to a secondary position.

Limitations to treatment can be shown by the use of cephalometrics and certain orthodontic cases with a very poor facial balance, high AB differences, will be better not treated.
Diagrammatic representations of cases illustrating first a severe apical base dysplasia, and secondly, a moderate basal difference. Inclination of the teeth is the same in both cases before therapy starts, but varies considerably after treatment.

Good facial pattern; upper incisors tipped labially, lower incisors lingually inclined.
Poor facial pattern; upper incisors tipped labially, lower incisors also procumbent. Heroic measures are necessary here for orthodontic treatment to provide a stable result. Sacrifice of lower premolars, despite the excessive labial tipping of the mandibular incisors, might make restoration of normal incisor contact very difficult.

Cephalometrics as well as a diagnostic criterion and a guide to treatment procedures is also most useful in measuring the progress of a case under treatment. Graber's article is valuable in that it emphasises the necessity of comparing relative positions of structures and teeth within the same individual and not relying on means for prognosis of cases. Treatment aimed at arriving at axial inclination of incisor teeth in harmony with normal values is condemned by Graber in cases of poor facial balance. There must be compromise in treatment and more so particularly in cases of skeletal dysplasia. Cases in which the best must be made of a bad job will be indicated by cephalometric analysis and if we disregard the warnings, the result of treatment will be a failure.
A study by Johnson (9) is intended to explain how and why the facial pattern is bad when the Frankfort mandibular plane angle becomes increasingly large. Facial patterns which are determined by hereditary are of the utmost importance in orthodontic prognosis and treatment. Extremes of deviation of the individual pattern from the so called normal and ideal pattern put the individual in some cases outside the pale of orthodontic treatment.

The size of the Frankfort mandibular plane angle must be regarded as the result of relatively greater development in certain areas of the face than in others. The Frankfort mandibular plane angle is affected by three factors according to Johnson.

1. Vertical development of the alveolar process in the anterior portion of the denture. Patients with a large angle indicating a bad prognosis for treatment showed a long profile and increased dimensions in both upper and lower face height. The length of the ramus although relatively short in these cases was not the prime factor in this facial pattern but rather the excessive development of the alveolar process in the anterior segments. Reference to these cases as "short ramus" cases is wrong therefore.

2. The absolute length of the ramus. When the Frankfort mandibular plane angle is small the length of the ramus is of importance. These cases of low angulation are of two classes.

(a) A pleasing facial type with the bony outline well formed beneath the soft tissues and a gonial angle approaching 90 deg.

(b) In contrast there is the severely closed bite case and the facial pattern cannot be classed as good. An increase of vertical dimensions by orthodontic treatment brings an improvement in these cases.

3. The infero-superior placement of the glenoid fossa in the skull. The advantage of a long ramus may be
negatived by a high position of the condyle in the skull this virtually making the effective length of the ramus short with a corresponding increase in Frankfort mandibular plane angle.

Johnson also found that statistically there is a relation between the size of the gonial angle and the Frankfort mandibular plane angle. He concludes that where the angle under discussion is less than 25 deg. a more or less distinct facial type is encountered especially as regards aesthetics and prognosis for treatment.

This article by Tweed (10) on the Frankfort mandibular incisor angle is an attempt to establish this angle as a further guide to the orthodontist in his search for a stable dentition and a better aesthetic result in his cases. Tweed stresses the need for lateral head X-rays prior to treatment and if necessary during treatment as well as after treatment. The primary object is to establish the lower incisors at an angle of at least 65 deg. to the Frankfort horizontal plane. In Class I case treatment the lower incisors must be retracted to this angle and if insufficient space is present extraction must be resorted to.

In Class II cases the lower incisors must be retruded to an angulation of 70 deg. to the F.H. plane when anchorage is being prepared to allow for a relapse of 5 deg. when the lower arch is being used as anchorage for inter-maxillary traction. While Tweed's results in treatment are excellent I think some danger lies in others lacking his technique and experience emulating his example and following his rigid rules of angulation of incisors. Tweed warns that his F.M. I.A. of 65 deg. is no panacea but that in 90% of cases the facial aesthetics will be improved to the good to excellent rating. However he says there are some patients who require an F.M. I.A. of as much as 75 deg. to obtain their best in facial balance.
In his cephalometric analysis Sassouni (11) uses the planes, points and areas shown below.

He has originated two new planes in this study.

1. Anterior Cranial base plane or basal plane 0.5. A plane parallel to the axis of the upper contour of the anterior cranial base and tangent to the inferior border of sella turcica.

2. Ramal plane R.X. a plane tangent to the posterior border of the ascending ramus.

DEFINITION OF WELL PROPORTIONED FACE.

(a) The four planes used if continued posteriorly will all meet together at the same point 0 in a well proportioned face.

(b) Pogonion, incisal edge of upper central, anterior nasal spine, nasion and the fronto-ethmoid junction are all equidistant from 0.

(c) Gonion and posterior wall of sella turcica are equidistant from 0 and thus the anterior cranial base and the corpal length of the mandible are equal in length and position.
CLASSIFICATION OF FACIAL TYPES

Type I.
Wherein the anterior cranial base plane does not meet the three other planes at O.

Type II.
Wherein the palatal plane does not meet the other three planes at O.

Type III.
Wherein the occlusal plane does not meet the other three planes at O.

Type IV.
Wherein the mandibular base plane does not meet the other three planes at O.

SUBDIVISION

In each of these types the plane which does not meet the three others at O may pass either (A) above or (B) below that point. Thus we have the subdivision to each type of A & B.

VERTICAL PROPORTIONS

Lower face is compared to upper face in height using palatal plane as dividing line and ANS for anterior face and PNS for posterior face.

CLASSIFICATION OF THE PROFILE

Based on the relation of the points of reference of the profile to the anterior arc.

1. Archial
2. Prearchial
3. Postarchial
4. Convex
5. Concave

A complete, well proportioned face in one in which

1. The four facial planes meet at the same point O
2. Anterior upper and lower faces are equal
3. Posterior upper and lower faces are equal
4. Profile is archial
5. Posterior arc passes through dorsum sella turcica and gonion.
There may be numbers of well proportioned faces as it is a question of proportion and not of absolute size.

**TEETH AXIS AND FACIAL PLANES**

The relations of the maxillary and mandibular central incisors and first permanent molars to the palatal plane and the mandibular base plane are pointed out by Sassouni.

**GROWTH STUDY**

Sassouni’s analysis enables us to study facial growth by using the point O as the fixed point by which to superimpose successive tracings.

There are two possibilities without treatment.

1. Facial angles do not change with a well proportioned face and well proportioned growth.

2. Facial angles change and we see disharmony between upper and lower face.

Treatment results will be sometimes reflected in a change of the planes to that of the well proportioned face with all planes intersecting at O.

**TREATMENT PLANNING**

Regarding diagnosis Sassouni says three viewpoints are possible.

1. A specific face can be compared to an ideal, and the decision is made by the orthodontist.

2. Specific face can be compared to an average face, and the type is derived from the majority of people.

3. A specific face can be compared to the optimum for that specific face, as presented in this analysis. Here the decision is set by the architecture of the patient's face itself.

Diagnosis should be carried out in the following sequence.

1. Determination of the malocclusion

2. Study of the facial proportions by means of planes and arcs.

3. Study of the axial inclination of the teeth and their relations to the planes.

Sassouni analyses three cases of malocclusion and points out
in what areas they deviate from his concepts of the well proportioned face. These deviations more or less then indicate the treatment which is necessary in order that they may be made to approach the essentials of well proportioned faces. In my opinion at this stage the writer has been overcome by his enthusiasm for his theories and seems to have forgotten the limitations of orthodontic treatment. One treatment plan he blithely suggests.

1. Bring the mandible forward, since both pogonion and gonion are posterior in position.

2. Bring the premaxillary area downward since there is an imbalance between upper and lower anterior face heights.

In the treatment plan for his third case he says, "We cannot directly change the anterior cranial base line. Therefore although this patient has a Type IA facial pattern we will consider it as Type II face and try to correct the disproportion by bringing the palatal and occlusal planes to point O; that is, we will bring the ANS downward."

Sassouni at least realises that treatment cannot directly change the anterior cranial base plane but infers perhaps that it may be changed indirectly. I believe that treatment changes such as Sassouni suggests to correct his disproportions are beyond the scope of any orthodontist.

**FACIAL PATTERN AND MALOCCLUSION.**
The writer states that if a malproportioned facial pattern can be associated with a good occlusion, we have not found any well proportioned facial pattern associated with malocclusion. I consider that Sassouni's concept of the well proportioned face is much too rigid.

While I do not wish to throw doubt on Sassouni's measurements and data I find it hard to believe that eight anatomical points joined in pairs as in this analysis and extended posteriorly would meet at a common point in 16 out of 100 cases. And this is only the first of the criteria which must be fulfilled for his concept of the well proportioned face.
Sassouni has noted in a limited number of cases that cephalo-
facial architectural pattern may run in family lines. 
In the twelve parent child comparisons three have the same 
total facial angle, five have the same upper angle, four have 
the same lower facial angle. 
This research is worthwhile contribution to the knowledge of 
the pattern and architecture of the facial skeleton in both 
normal and abnormal proportions. I think the value of the 
immense amount of work which must have gone into this study 
will be mainly in the field of research as its use in diagnosis 
and treatment planning would not seem to have any advantage over 
the very thorough analytical methods of Downs, Graber and Wylie.

Bjork (12) gives an excellent summary of the importance 
cephalometry has assumed in orthodontics. He traces the 
development and research work in seven divisions.

1. X-RAY TECHNIQUE
The method of Broadbent has remained unaltered since its 
introduction in 1931 with a few minor variations.

(a) Tangent film distance has been altered in 
some instances.

(b) Bjork advises that the head be oriented in 
natural balance instead of according to the 
P.H. plane. This obviates the strained posit-
ion of the face which interferes particular-
ly with lateral pictures of functional posit-
ions of the lower jaw and the rest position.

(c) Wedge shape block of aluminium enables soft 
tissue to be portrayed in the profile X-rays.

(d) Tantalum powder used as a suspension in 
water and brushed over the soft tissues will 
provide a satisfactory contrast.
2. **REGISTRATION METHODS.**

The sella turcica point and the nasion-sella turcica line are the most stable and most useful reference points and line, and displacement of these references during growth is very slight. Bjork says that the Frankfort horizontal taken from the field of craniometry cannot be identified on X-ray projections and is therefore of no practical value in the analysis of X-ray profiles.

3. **MORPHOLOGICAL INVESTIGATIONS**

Cephalometric X-ray investigations into variations in the shape of the facial structures have been frequently performed usually on a small number of cases with the object of providing a basis for clinical analysis rather than comparative studies. Recent studies include those of Downs, Margolis, Higley and Hill.

Bjork in his studies has shown the relation of the face to the cranial base and the connection between the variations occurring in different parts of the skull and the effect of these variations on others.

Racial differences in crania can be readily studied by this method and some work has been done by Bjork on this subject. The chief limitations of the X-ray method is that it does not permit the same possibility of studying transverse development of the cranial structures. This difficulty will probably be overcome with the development of laminography.

4. **GROWTH AND DEVELOPMENT.**

This phase has been studied in cross-section and longitudinal investigations by various writers.

Bjork warns that the cross-sectional studies do not provide any indication whatsoever of individual variations in development and this is probably why the facial pattern is considered by many to remain more or less unchanged throughout the growth period of the individual. The majority of studies are based on an insufficient number of cases for the purpose of providing information about the interdependence of variations, added to which the material is usually treated in the same manner as
cross-sectional studies so that much of the essential information is missed.

Growth studies have been made, in cases of endocrine disturbances, obesity, rheumatoid arthritis and in cases of facial clefts.

5. **DIAGNOSTIC METHODS.**

Diagnostic analytical methods have been devised by many investigators among which the method of Downs is the most comprehensive. The use of cephalometric X-ray analysis in orthodontic diagnosis has greatly advanced the understanding of the aetiology of malocclusion and has brought about radical changes in therapy.

6. **CONSTITUTIONAL RESEARCH.**

The use of the X-ray has made possible a comparison between cranial build and the build of the whole body. Cranial development and maturation can be related to the developmental features of the long bones of the skeleton.

7. **FUNCTIONAL ANALYSIS**

Thompson's research on the rest position of the mandible has been outstanding and this has, been followed by the work of Ricketts on the condylar movements. Investigations carried out on the alteration of the mandibular position after treatment indicate that any alterations affected in this way are most cases very slight.

This is a very informative summary by Bjork which places some considerable doubt on some of the findings of American investigators mainly because of the meagreness of their material from which they draw rather definite conclusions.

The work of Bjork (3) on the face in profile is an attempt to analyse the nature of prognathism and to investigate certain problems connected there with especially those concerning the occlusion of the teeth.

Bjork employed profile X-rays and used the following planes and angles in his measurements.

A line drawn from the apex of the anterior nasal spine to nasion to centre of sella turcica, to articulare, to the
point of intersection between lines tangent to the base and ramus of the mandible and to pogonion and infradentale. The effects of decrease or increase in the dimensions of these lines and angles is presented and illustrated in diagrams.

1. Reference points employed.
2. Diminished saddle angle (decrement 10 deg.)
3. Diminished joint angle (decrement 10 deg.)

1. Diminished jaw angle (decrement 10 deg.)
2. Increased chin angle (increment 10 deg.)
1. Enlarged ramus height (increment 10mm)
2. Elongated lower jaw (increment 10mm)

Horizontal part of cranial base shortened (decrement 10mm).
2. Vertical part of cranial base shortened (decrement 10mm).
Enlarged facial height (increment 10 mm)
Prognathism may be total or confined to the mandible or maxilla. Maxillary prognathism is caused by diminution of the angles at the sella turcica and the temporo-mandibular joint and an increased chin angle.

A shortening of the forward part of the cranial base and an increase in the length of the jaws also contribute to the degree of prognathism. Bjork gives possible causes of mesiodistal deviation of the occlusion of the teeth as follows.

1. A relative difference in the size of the jaws, due to the increased length of the maxilla or conversely a reduction in the size of the mandible.
2. Differences in alveolar prognathism producing local changes in the alveolar arches alone.
3. Prognathism due to the inclination of the incisor teeth.
4. Mobility of the mandible in a forward direction at the temporo-mandibular joint.

The most significant cause of increased maxillary prognathism and overjet is that caused by differences in the size of jaw length. With regard to crowding of the teeth Bjork found this to occur in persons with a reduction in the length of the faces. Contrary to Tweed's theory there was no significant difference with respect to the inclination of the mandibular or maxillary incisors in persons with crowding or without crowding of the dental arches. In his study of twelve year old boys Bjork found that mandibular prognathism was relatively smaller than maxillary prognathism in comparison to that found in adults.

This would suggest a straightening of the facial profile in the adult. On the other hand the relative increase in mandibular prognathism during growth period is equalised in some measure at the chin angle which becomes smaller.

This was the only angular change found during growth by Bjork. Bjork's work confirms Brodies findings with regard to constancy of angular and linear growth of the jaws with the exception that Bjork found that there is an increase in
angle of prognathism and a reduction in the chin angle in adults in comparison to the twelve year old group.

Facial diagram constructed from mean values for entire conscript material. Angular and linear variations ranges are indicated by means of thin lines.

Facial diagram constructed from mean values for the entire boy material. Angular and linear variations ranges are indicated by means of thin lines.
Bjork (14) enumerated the following factors in determining the formation of the face and dentition.

1. Evolutionary changes found in the ascending series of vertebrates.
2. The factors which determine the different cranial and bite formations in existing human races.
3. The factors responsible for variations in formation within the same racial group.
4. The growth changes that take place in the individual.
5. The effect of domestication or civilisation on primitives.

The effect of racial mixture on the facial skeleton and the dentition.

Bjork used the x-ray in his studies as the only means to give the data he required.

He defines prognathism as the characteristic which determines the general shape of the facial profile.

Pritchard defines prognathism as the prominence of the facial skeleton in relation to the brain case.

On X-rays it may be measured by the angle formed between the facial profile and the cranial base and Bjork uses the Sella turcica - Nasion plane of Brodie as his reference plane.

The degree of prognathism is then determined by the angle between this S-N plane and lines drawn from the nasion to different points on the facial skeleton.

Facial prognathism refers to the prominence of the facial skeleton as a whole while alveolar prognathism indicates a protrusion of the alveolar arches beyond the jaw bones.

Bjork concludes that facial prognathism may arise in the following ways.

1. Due to a shortening of the cranial base.
2. Due to angular bending of the cranial base.
3. Due to changes in the shape of the facial skeleton which cause the angle formed between the ramus and the cranial base to diminish.
4. Due to increased jaw length.
These different factors may combine in different ways with various effects.

1. **EVOLUTIONARY CHANGES**.

Facial structure and dentition have passed through a great many evolutionary changes and these changes may be summarised thus.

The prognathism diminishes because of a shortening of the jaws and a shortening and deflection of the cranial base also occurs.

2. **RACIAL VARIATIONS**

Bjork compared the nature of prognathism in the two races of Swedes and Bantus and found that the greater prognathism of the Bantus relative to the Swedes is largely a matter of the larger size of the jaws.

3. **INDIVIDUAL VARIATIONS**

The degree of individual prognathism depends mainly upon the degree of prominence of the facial skeleton as a whole due to a shortening and bending of the cranial base. Along with this bending of the cranial base we have a more forward location of the foramen magnum and the spinal column on the underside of the skull.

**ONTOGENETIC CHANGES.**

The prognathism of both jaws increases with age. The increase in mandibular prognathism being greatest, the incisors become more erect and the chin less recessive.

**DOMESTICATION**

This study of domestication has been more widely investigated in animals which have lived in captivity than in humans who have come under the influence of civilisation.

From the viewpoint of morphology the effect of domestication is to widen the range of variation. In animals the effect of domestication is that the degree of prognathism is reduced by a shortening of the jaws. If the same applies to the human race it would explain the crowding of teeth in the smaller jaws.

**RACIAL MIXTURE**
RACIAL MIXTURE

Degree of prognathism may be different in each jaw. These differences may arise in two different ways according to Bjork. Firstly the relative size of the jaws and secondly and most important the relative position of the jaws.

Bjork says that the previously used methods of measuring the degree of prognathism from the Frankfort plane have not been able to demonstrate the manner in which the cranial base influences the prognathism and the occlusion. The highest degree of correlation between maxillary and mandibular-prognathism will occur in unmixed races and the correlation will diminish with racial admixture. Changes in molar occlusion are very rare in other primates, the species and racial groups of which are more clearly defined.

In racial mixture as in domestication the trend would also appear to be for greater range in variety and also a reduction in the correlation, between the maxillary and mandibular prognathism.

A distinction must be made between facial prognathism and alveolar prognathism for the purpose of this article by Arne Bjork (15).

1. Facial diagrams for measuring variations in the facial structure and the cranial base from a lateral X-ray exposure.
2. Diagram indicating the method of measuring the angles of prognathism and the inclination of the incisors from a lateral X-ray exposure.
FACIAL PROGNATHISM refers to the protrusion of the facial structure as a whole.

ALVEOLAR PROGNATHISM indicates a prominence of the alveolar arches beyond the jaw bases.

FACIAL PROGNATHISM may arise in several ways

1. Due to a shortening of the cranial base.
2. Due to an angular deflection of the cranial base.
3. Due to the changes in the shape of the facial skeleton which cause the angle formed between the ramus and the cranial base to diminish.
4. Due to the increased jaw length.

VARIATIONS IN SAGITTAL OCCLUSION

The three main causes of maxillary overjet are

1. A relative difference in basal prognathism
2. A relative difference in alveolar prognathism
3. A change in the maxillary overjet may also occur due to the inclination of the incisors.
Relative differences in basal prognathism may arise from one of the factors below.

1. Relative size of the jaw bases.
2. Relative position of the jaw bases which may be due to
   (a) Long cranial base
   (b) Relatively straight cranial base
   (c) Ramus inclined rearward.
3. Mobility of the jaw joint

The three main causes of maxillary overjet shown by the broken lines:
   a. A relative difference in basal prognathism.
   b. A relative difference in alveolar prognathism.
   c. Inclination of the incisors.

The 3 causes of mandibular overjet are
1. A relative difference in basal prognathism.
2. Relative difference in alveolar prognathism
3. The inclination of the incisors may also affect the overjet.

The three main causes of mandibular overjet shown by the broken lines:
   a. A relative difference in basal prognathism.
   b. A relative difference in alveolar prognathism.
   c. Inclination of the incisors.
Diagrammatic sketch showing the significance of the formation of the cranial base in relation to changes in occlusion. The jaws are the same size in all the diagrams. 

b. depicts normal occlusion when the jaws and the cranial base are in proportion. If the cranial base is elongated (a) a corresponding increase is obtained in the maxillary overjet. If on the other hand, it is shortened (c) the relative position of the jaws is altered to produce mandibular overjet.

Prognathic factors which may affect the lower jaw more than the upper jaw, are:

1. Relative size of the jaw bones
2. Relative position of the jaw bones
   (a) Short cranial base
   (b) Deflected cranial base
   (c) Ramus inclined forward
3. Mobility of the jaw joints

The mandibular overjet is increased by a forced bite as the jaws are closed.

While Bjork's methods and material are of interest from a research point of view I consider Downs' or Graber's analysis of facial and alveolar prognathism much simpler and more easily applicable in clinical diagnosis. Bjork studies all the variable factors that may produce the anomalies, however the more direct measurements of the results of the variables as shown by Graber's SNA. SNB measurements and Downs' figures would be of more value to the orthodontist in practice.

This article by Bjork (16) is limited to a discussion of the relations of the incisor teeth, in sagittal and vertical direction. An interesting opinion is given by Bjork which is part of the more practical approach to the solution of many orthodontic problems. "From a functional point of view the
deviation in the occlusion of the front teeth is of greater importance than a determination of an anomalous position of the molars, which does not necessarily require adjustment if the bite is otherwise functional, well balanced."

Overjet and overbite are correlated but this relationship cannot be expressed in the form of a straight line. However starting from an edge to edge bite the overbite increases when the overjet increases in a positive direction. Thus when the maxillary overjet is large the depth of overbite is generally larger. As age advances from 12 to 20 years, Bjork found that both overbite and overjet decreased but there appeared a great individual dissimilarity.

Overjet is more variable than overbite both at 12 and 20 years. In some individuals there is a marked forward displacement of the front teeth of the lower jaw the maximum in the cases studied being 4.8 mm. In the sagittal molar occlusion the movement due to age change may be within the limits of \[ \pm \] cuspal width with greater tendency toward forward movement. The primary type of bite affects changes to be expected. Deep overbites show a greater tendency to open than normal overbites whereas open bites show a tendency to close.

These findings of Bjork are interesting in that they are some guide as to what we may expect without treatment or what changes may take place to expedite treatment. However the stress that Bjork places on the fact that great individual variability is disclosed in his study must be a warning to regard these changes as possibilities and not by any means certain to take place.
Lundstrom (17) says that the aim of all orthodontic treatment should be to convert inferior dentitions into satisfactory ones.

(a) Functionally in respect to chewing, speech, and breathing

(b) Prophylactically in respect to caries, periodontal and joint diseases.

(c) Aesthetically.

As far as the third treatment aim is concerned, i.e., aesthetic improvement, this is a purely subjective matter for the judgement of the operator in each individual case and no idealistic norm or mean result will be satisfactory to all concerned.

Lundstrom warns that readings from cephalometric tracings must be interpreted with reserve in some cases.

He quotes the Y-axis angle of Downs and suggests that the degree to which this angle can be used as an indication of the forward growth of the lower jaw is uncertain because the angle is determined partly by the height of the face. Therefore in the interpretation of the size of this angle the facial height has to be taken into account.

The Frankfort mandibular plane angle of Tweed must be also treated with reserve.

Lundstrom urges a careful study of the freeways space and the path of closure as introduced by Thompson, particularly in prenormal occlusions.

He claims that it is possible by a study of these two factors to distinguish between "the true prognathous jaw with abnormal forward development or forced prenormal occlusion."

Extensive material must be investigated before changes can be claimed for treatment as shown in cephalometric analysis of before and after X-rays. The growth and development which coincide with the treatment period must clearly be responsible for a fair amount of changes, claimed by some workers to be the results of their treatment procedures.

Lundstrom is another writer who condemns the importance placed on means and variation ranges derived from cases of so
called anatomically correct occlusions. He emphasises the fact that the use of cephalometrics has not been investigated sufficiently from the clinical angle particularly as a means of assessing the changes claimed for orthodontic treatment.

This article by Lundstrom is essentially a summary of various researches in cephalometry and their implications.

In this article Lewis (18) presents an interesting summary of the various workers in this field and some of their main findings from the inception by Broadbent of the technique to the researches of Thompson published in 1949.

Baum (19) has devised a less involved system of applying the Downs analysis directly to individual films in a similar fashion to Wylie and Johnson.

In this case Baum has designed four template transparencies. Template No.1.

Template 1; for determination of facial angle, mandibular plane angle and Y axis.
Template 1; orientated over head plate for determination over facial angle. Note nasion reference point of the template on nasion of the X-ray; and the Frankfort Horizontal Grid lines of the template parallel to the Frankfort Horizontal plane of the X-ray. Facial angle is read from the location of pogonion with reference to the lines radiating from the nasion reference point. The dashed centre line indicates the mean facial angle of 88 Deg. The solid lines on either side delineate normal range. The actual numerical value of the facial angle in this case is 91.5 Deg.

For the determination of:

A. Facial angle
B. Mandibular plane angle
C. Y-axis

Template No. 2

Template 2; for determination of angle of convexity and angle of AB Plane to facial plane.
For the determination of
A. Angle of convexity
B. Angle of AB Plane to facial plane

Template No. 3

Template 3; for determination of the angle of the axis of the upper central incisor to axis of the lower central incisor, the angle of the axis of the lower central incisor to the mandibular plane, and the angle of the axis of the upper central incisor to the axis of the lower incisor.

For the determination of
A. Angle of the axis of upper central incisor to the axis of the lower central incisor.
B. Angle of the axis of the lower incisor to the mandibular plane.

Template No. 4

Template 4; for the determination of cant of the occlusal plane, and angle of the axis of the lower central incisor to the occlusal plane.
Fort the determining of
A. Cant of the occlusal plane
B. Angle of the axis of the lower central incisor to the occlusal plane.

Baum says that the transparency system is not only a means of rapidly and simply analysing cephalometric X-rays but is also useful in demonstrating to parents the implications of a diagnosis.

Wylie and Johnson (20) while realising and admitting the value of angular readings of lateral head tracings as instanced in the Downs' analysis make a plea for the use of absolute linear measurements. They say that if these are utilised with commonsense they can provide much information. The writers admit that although Wylie's analysis of antero-posterior dysplasia was important it has become apparent that vertical dysplasia must be considered at the same time.

The Frankfort horizontal mandibular plane angle serves to record the amount of vertical dysplasia but does not localise it. The points and lines of measurements used in this study of vertical dysplasia are illustrated best by the following.

Landmarks and planes used in this report.

1. It was shown that in good faces the condylar angle was less than it was in fair and in poor faces it was greatest.

2. Lower border of the mandible is longer in good faces than in fair and in poor is shortest of all.
3. Adequate length of ramus was shown to be necessary for a good face.

4. As face height becomes larger so does face pattern become worse.

5. The summit of the condyle should be on the Frankfort horizontal line or below it.

The authors have made from their measurements the two transparencies shown below.
which may be placed on and compared to any lateral head film
and the assessment of vertical dysplasia arrived at.

Pruzansky (21) classifies clefts into four sections.

1. Those involving the lip alone
2. Those involving the lip and palate
3. Those in which the palate alone is affected.

The greater the cleft in the lip the greater the effect on
the alveolar process but this relation does not obtain in
the palate itself. The defect in the alveolar process is closely
related to the number of teeth in the deciduous and permanent
dentition affected.

2. CLEFT LIP AND CLEFT PALATE. These may be unilateral or
bilateral and a great range of variation exists in each cat-
egory. These clefts may be complete or incomplete and if in-
complete they may be symmetrical or asymmetrical.

3. CLEFT PALATE in which category neither the lip nor the
alveolar process is involved. They may involve only the soft
palate or the soft and hard palates but never the hard palate
alone. Cleft palate patients have very often the accompanying
deformity of mandibular micrognathia.

4. CONGENITAL INSUFFICIENCY OF THE PALATE. This anomaly
is seldom apparent at birth and the first indication is when
the child develops the hypernasality characteristic of un-
corrected cleft palate speech.

ANALYSIS OF THE DEFECT. Necessitates evaluating the records
of each child from birth onwards.

A. Distortion of parts by muscle action
B. Adequacy of parts
C. The spatial relationship of the anatomical segments
D. What is the relationship of the palate to contiguous
   anatomical structures?

The removal of tonsils and adenoids can aggravate the speech
defects in cleft palate cases.

E. The fourth dimension of time. The author stresses
the necessity of the employment of the above divisions as a means of describing clefts of the lip and palate. Photographs, casts of the face and palate and cephalometric X-rays are necessary records by which to follow growth of the child involved and in planning long range as well as any immediate treatment.

Representations of the most common clefts of the lip and palate. All of these casts were obtained in infants and young children prior to any surgical procedure.

Varieties of unoperated cleft palate.
Graber (22) compares treated and untreated facial cleft cases with dimensions of facial proportions of cases of normal occlusion.

3. Cephalometric planes and landmarks: S – sella turcica; N – Nasion; Pty – Pterygomaxillary fissure; O – orbitale; A – subspinal; B – supramentale; P – pogonion; Gm – gnathion; Gg – gonion; P – porion.

4. Case R.P. Cephalometric tracing showing marked lack of vertical and antero-posterior maxillary development – palate and lip have been closed by a series of 15 surgical operations.

5. Case B.Q., age 8. 20 mm. freeway space allows mandible to overclose into dotted outline. occlusion.

6. Case M.A. Despite "normal" occlusion, a concave profile and excessive labial inclination of upper incisors demonstrate limitations of orthodontic therapy.

Maxillary growth was found to be restricted in all cases and particularly in those cases which have had early surgical intervention. It has become apparent that surgical correction will in some instances limit the growth potential of the maxillary denture. Normal lateral growth is present in those cases in which there is no history of surgical interference. Mandibular growth is found to be normal with an increase of freeway space over the normal as found by Thompson.

The clinical results of orthodontic treatment while improving the tooth relation do not stimulate any basal bone development and results are unstable and have to be maintained indefinitely.

Graber concludes that possible early surgical interferences with
growth centres cannot be compensated for later by orthodontics.

Downs derived his values from studies of white American subjects and Cotton, Takano and Wong (23) have tested its application to other racial groups namely; American negroes, Nisei and American Chinese. These three authors in separate studies found that Downs' figures were not applicable in these three groups. These articles and their results seem rather useless to me and totally devoid of any practical application. The research time, I consider would have been better spent in studying larger numbers of each group (instead of twenty) and formulating means and ranges for Downs' ten measurements for each racial group.

(24) Speidel, urges the diagnostic analysis of the developing occlusion of a child patient.

1. To determine what already has happened in the child's dentition and adjacent structures.

2. To understand why the observed conditions have occurred.

3. To foresee what changes are most likely to occur if no treatment is instituted.

4. To decide what might be done to improve both the present and future condition of the patient's occlusion.

One diagnostic factor is the sequence of eruption of the permanent teeth. Perhaps most frequent malocclusion seen is where there is lack of space between mesial surfaces of each first permanent molar.

This may be due to misproportion of mesial drifting from too early extraction.

Sometimes first molar tips mesially and sometimes does not.

**INFLUENCES ON TENDENCIES TO TIP MESIALLY**

1. Mesial contact support of teeth
2. Occlusion with opposing teeth
3. Axial inclination of first molar relative to axial inclination of opposing teeth
4. Eruption sequence of second molar relative to bicuspid s and cuspid eruption

1. The more continuous the contact support is, the less chance for mesial tipping. Permanent teeth erupt very promptly as each deciduous tooth is lost. Slight movement of mandibular first molar occurs during eruption of second bicuspid.

2. Occlusion of the first molars
Correct intercusp ing will resist mesial tipping of first molars

3. Axial inclination of molars relative to each other related to tendency to tip forward according to Brodie. If both are inclined mesially to a slight extent and the greater the inclination, the greater the tendency to tip apparently.

4. Eruption of second molar
The question is "Is it possible that eruption of the second molar in the period of cuspid and bicuspid eruption makes it more likely that the first molar will tip mesially than if the second erupts after the cuspid and bicusps erupt?" What small evidence there is seems to show that the second molar does cause some mesial tipping when it erupts before the bicusps and cuspids.

The pattern of the mandible is stabilised early in life, at the age of three months and providing growth and development proceed normally this pattern is maintained throughout life. Dr. W.N. Benson (25) in his thesis studies the limitations which are imposed on successful orthodontic treatment by deviations from the normal development of the mandible in form and degree.

A comprehensive review of research in the development and growth of the mandible and the eruptive processes of the teeth is given.
The thesis goes on to deal with the standards of occlusion and malocclusion particularly those of Angle and Simon. The concept of a rigid standard from which deviations may be judged is condemned by Benson in these words.

"Any anatomical point must be characterised by the same phenomenon of normal variation, and the desire for a fixed point or plane, from which to judge deviations of denture relations, is evidence of ignorance of the morphologic variability of living organisms." The angular relation of the ramus to the body of the mandible remains constant during normal development but because there is a change in the position of the condylar head especially up to seven years of age, Benson says there is a decrease in gonial angle. An increase in the gonial angle in later life is associated with normal occlusal wear. These are normal variations and must not be associated with the abnormal trends typical of malocclusion. Therefore it may be postulated that any alteration in the relation of the ramus to the body of the mandible constitutes an abnormal trend.

The axial relation of lower incisors to the occlusal plane is ideal aesthetically and most stable according to rweed when the angulation is 90 deg. ± 5 and in treatment the objective should be to align the incisors within this range. Benson regards this range as being too narrow because of the wide individual variations found even in normal occlusions, however as an additional guide from which to judge the deviation of cases from normal it is of importance.

Of the 191 cases of Class I and Class II Division I malocclusions studied the mean incisor axial relation was found to be within 90 deg. ± 5 in both groups, the Class II group having a significantly higher angle than the Class I. A relationship was found between the gonial angle size and the class of malocclusion. In Class I and Class II Division I groups there was found to be a marked relation between the gonial and incisor angles. These two angles were found to vary inversely. The incisor angle is
subject to wide variations and before any conclusions for case analysis are drawn from its inclination it is necessary to also consider the gonial angle of the subject concerned.

The purpose of work by Corlett(26) in mandibular incisors is the analysis by means of standardised lateral head X-rays of the relation of the lower incisors to the basal bone of the mandible.

The theory of the forward translation of teeth or their drifting anteriorly in relation to the basal bone has found wide favour since Grieve in 1937 propounded the theory. Tweed has become one of the main proponents of this forward drift theory particularly in Class 1 cases. Since the mandibular teeth have been probably the worst offenders, steps have been taken by various workers to try and establish what is the correct inclination of the incisors to basal bone or the mandibular plane. Individuals having good occlusion seem to have incisors at a fairly constant angle. Also cases treated and with incisors brought to about the angle seen in the normal occlusion seem to be stable. Tweed's experimental finding on cases of normal occlusion showed that the incisors are always positioned on mandibular basal bone at an angle of 90 deg. ± 5.

Tweed's models were cut parallel to the occlusal plane so that his measurements must be related to this plane and not to mandibular basal bone as he implies. Brodie, Margolis, Speidel and others used X-rays and found that Tweed's figures were substantially correct. They used the mandibular plane as a base.

Higley (1944) emphasised the importance of the position of the incisors relative to the basal bone of the mandible and also in respect to the menton.

Specific Aims of this study.

1. Relation of lower incisors to bony base of mandible in patients with normal dento-facial relationships.

2. Relation in Class II type.
3. Relation according to age and sex.

SUMMARY AND CONCLUSION

452 Lateral cephalometric X-rays were used
375 Normal or Class I
79 Class II

Study showed that lower teeth have approximately the same relative position to the basal bone in Class II deformities as in normal occlusion Class I malocclusions.

Inclination to the mandibular plane or incisal plane is not as important as the position of these teeth with respect to basal bone.

This study was primarily concerned with the relative position of the lower incisor crowns to the menton without much attention being given to the inclination of the incisors or the position of the root apices relative to the basal bone.

Prognathism is one of the most incorrectly used words in orthodontia and strictly applies to a forward position of the lower jaw in relation to the skull according to Marshall (27). However common usage has made the word apply to either the maxilla or mandible.

1. Maxillary prognathism is a condition in which the maxilla lies in front of the cranium as a protruding maxilla.

2. Mandibular prognathism is a condition in which the maxilla lies under the front part of the cranium and the mandible projects in front of the head as an overdeveloped mandible.

3. In bi-maxillary prognathism the maxilla and mandible project in front of the cranium.

Tomes and Dolomore applied Wolff's Law to the temporomandibular articulation and assumed that the form of the joint was determined by the function of the teeth. They also postulated a migration of glenoid fossa in the temporal bone as a result of changes in the occlusion.

Opposed to this functional concept was Todd who held that
temporo-mandibular joint form has nothing to do with the function of the teeth.

Brodie's studies more or less supported Todd and his findings suggested that jaw articulation like other parts of the skull was determined primarily by hereditary factors with mechanical or functional factors playing a secondary role. Thompson and Brodie have since observed that the position of the mandible is largely due to a suspension by the musculature involved and that its position is the same regardless of the presence or absence of teeth. They found that all movements concerned ended at the rest position.

METHODS used by Ricketts (28) in his work entailed the use of cephalometric laminography as cephalometric head plates do not show the area of the condyle. Laminographs were taken of fifty patients in

1. Rest position
2. With teeth in occlusion
3. With mouth wide open

A typical laminogram tracing is shown below.
Frontal view of skull with stippled area showing the depth of laminographic film.

FINDINGS

1. Morphology of the joint was the first study with reference to the comparative size of the condyle to the fossa. The articular elements of the temporal bone and the mandible appear to be independent variables and apparently there is not the functional adaptation to one another as claimed so frequently.

FUNCTION

2. Rotation of the condylar head was found to be the main movement in 85% of the control cases but in the Class II cases one third of the cases exhibited a marked translatory movement greater than in any of the control groups.
Method employed in analysis of movement of condyle.

Characteristic behaviour in movement from rest to occlusion in about 35 to 40% of Class II cases.
3. **RESTING POSITION OF THE CONDYLE**

   The condyle in the Class II cases was generally more downward and forward than in the control cases although when the teeth were clenched the positions of the condyles in the fossae were similar for both groups.

4. **TOOTH RELATIONSHIP**

   A study of the path of closure revealed that the mandible did not necessarily travel upward and forward. Variations are noted from an upward and forward to an upward and backward direction as shown below.

Path of closure variation in the control (left) and Class II (right).

The variations in interocclusal relationship in the rest and closed position are shown below.
Interocclusal dimension in the control (left) and Class II (right).

Summing up, Ricketts says that the size and form of the condyle head and the fossa are widely variable and independent of each other as regards correlation of form and size. Marked variation was found in the depth and location of the fossa, its relation to the Frankfort horizontal plane and the slope of the articular eminence. The same range of variation was found in both the control group and the Class II malocclusions. Joints in resting position showed a most significant difference in relation in control group and Class II malocclusion.

Between the two divisions of the Class II cases it was found that Division I cases exhibited a more posterior closing movement than did the Class II Division 2 cases although the latter presented wider interocclusal dimensions.

In another study of joint relationships Bowman (29) found that paths of closure changed with age probably due to growth of the mandible in the condyle region. After treatment of Class II Division I cases the occlusion position of the condyle did not change but the rest position was altered. Bowman says that in order to correct a Class II Division I malocclusion in a satisfactory manner, mandibular growth must occur during active treatment.
The only measurement obtainable from antero-posterior head plates of the skull is the transverse dimension. All other results are not satisfactory.

The system of laminagraphs permits projection on X-ray head films of an selected plane on a body to the exclusion of all other planes. Brader (30) described his experiments and technique which he has standardised.

Tests were conducted to compare measurements of images made by laminagraphic projection and actual measurements on casts and discrepancies were found to be of the order of 0.5 mm. Applications of this field of measurements are many and the one disadvantage appears to be the expensive equipment involved.

A step by step summary of the technique of producing the laminagram is given by Brader.

The research by Thompson (31) on the rest position of the mandible is most important in its bearing on the diagnosis and analysis of malocclusion.

As well as the analysis of the occlusion of the teeth in a static position it is necessary, as we are dealing with living and moving tissue, to analyse malocclusion from a functional viewpoint. The basis for functional analysis is that the muscles are the dominant factors in establishing the position of the mandible. The rest position of the mandible is established before any of the teeth have erupted, is not altered by their eruption and remains the same after they have been extracted. The relationship of the mandible in its rest position to the maxilla is stable and it affords a reliable basis for the analysis of malocclusion and moreover this relation cannot be altered permanently by any dental or orthodontic means.

Functional analysis of the malocclusion with the mandible in the rest position demonstrates two factors.

1. The size of the intermaxillary clearance at the rest position.

2. Path of closure of mandible from the rest position.
Analysis of the size of the intermaxillary clearance or free way space and the presence or absence of anterior overbite of the teeth with the mandible in the rest position should give us an accurate insight into the problem of the deep overbite and whether it is the result of insufficient eruption of the posterior teeth, excessive eruption of the anterior teeth or a combination of the two. Overbite relations must be analysed and in most cases treated before other treatment is instituted. Thompson shows one case in which the freeway space exhibited a clearance of 14 mm.

Superimposed cephalometric x-ray tracings of an individual with the mandible at rest position.

------------- 9 years, 8 months.
- - - - - - 17 years.

Casts of three cases of malocclusion related with teeth in occlusion and at rest position.
Closure from rest position to occlusion:
(a) before treatment.
(b) after treatment.

Comparison of first and second occlusal cephalometric x-ray tracings of previous case.
Evaluation of the antero-posterior and lateral position of the mandible is the second phase of functional analysis. These two positions as in the vertical are established by muscular balance and the observing of the path of closure from rest position to the occlusal position and the evaluating of its degree of normality and abnormality are the criteria for determining whether or not occlusal position represents the true mandibular centric position. Thompson points out that the mandible may assume an accommodated position created by the occlusion of the teeth and may be deflected posteriorly, anteriorly or laterally. The position of the mandible with the teeth in occlusion does not give us as clear a picture of jaw relationship as when the jaws are in the rest position. Functional analysis therefore must be considered most seriously and primarily and occlusal relation regarded as of less importance.

Investigation of the relationships in rest position is most important in the differential diagnosis of Class I and Class II cases. A Class II case from the occlusion relation aspect may have a Class I relation in the rest position. Thompson says that the displacement of the condyle on closure that occurs in a large percentage of cases of Class II mal-occlusions probably explains the difference in clinical response, and often is attributed to growth, types of appliances and particular methods of treatment.

A functional diagnosis will go beyond the consideration of the movement of individual teeth or group teeth, and considers efficiency of the masticating mechanism as a whole.

In 1937 Milo Hellman published a study based on a group of normal occlusions which disproved the previously held concept that if the teeth were in normal occlusion the face would be normal. Hellman proved that although the occlusion maybe normal, wide deviations would be shown in other dimensions. Bushra (32) in a study of VARIATIONS ON THE HUMAN FACIAL PATTERN IN NORMA LATERALIS has as his objective the investigation of the

1. the degree to which the face swung out from under
the cranium.

2. Variability and correlations in intra-facial relationships.

3. Variability and correlations in dento-facial relationships.

4. Variability and correlations within the denture.

Forty individuals with excellent occlusions were used as subjects and while the results showed that no plane, angle or relationship was invariable enough to be used as a criterion for diagnosis, some would be suitable for the analysis and prognosis of malocclusions.

Baum (33) based his findings of normal skeletal dental patterns on a study of 62 children, equally divided as to sex and between the ages of twelve and fourteen.

The method employed was cephalometric X-ray studies and the landmarks and planes used were those employed by Downs.

The males were found to be more convex in the face than females probably because both the maxilla and mandible were found to be larger in the males.

Compared to an older group, the group studied by Baum had a more convex face and less upright incisors when they were compared to either the occlusal or mandibular plane and a more protrusive denture.

From 1937 onwards the Graduate School of Orthodontics at Illinois under the direction of Brodie turned out many important studies on the various aspects of orthodontics.

Adams (34) found no correlation between the gonial angle and the age of the subject and also no significant difference in the gonial angle in Class I and Class II cases. He found that the absolute dimensions of the mandible did not differ essentially in both Class I and Class II malocclusions and inferred from this that underdevelopment of the mandible is not a factor in Class II malocclusion.

An analysis of Class III malocclusions showed that the gonial angle was greater and other notable differences. Angle at gnathion was smaller, the occlusal plane formed a more acute angle with the mandibular plane and the antero-posterior width
of the ramus was less than that of younger individuals of the other groups.

Measurements in Elman's (35) study of the relation of the lower six year molars to the mandible were taken from lateral cephalometric films and consisted of Class I and Class II and a few Class III malocclusions.

Elman's findings indicate definitely that there is no essential differences in the manner in which the first molar is situated in the mandible in Class I and Class II malocclusions in so far as antero-posterior and vertical dimensions are concerned.

Jensen and Palling (36) used Broca's method of obtaining and measuring the angle made by the ramus and body of mandible. Although they term it the gonial angle it is what has been described by other writers the condylar angle.

Age changes and show a rather obtuse angle at birth becoming more acute and then after the loss of teeth in old age the obtuseness increases. The greatest decrease in angle was found in the first two years of life and particularly in the first five months. The size of the gonial angle according to the writers seems to be relatively independent of variations in antero-posterior direction but in cases of deep overbite the gonial angle tends to become more acute. Bjork found that on the average the gonial angle was increased a few degrees when mesial occlusion was present but no deviation was found when a distal occlusion existed.

In a cephalometric study Riedel (37) endeavoured to determine the constancy or variation in the relation of maxilla to cranium and mandible in malocclusion and in normal occlusion.

**FINDINGS**

1. The position of the maxilla measured at Point A. was found to be constant in both groups.

2. The mandible at point B. was found to be more posterior in position in Class II malocclusion. Prognathism was found to increase with growth.

3. Relation of point A to point B was found to be more variable in the malocclusion cases.

Riedel analyses the inclinations of the anterior teeth in
both groups and says that the position of the upper incisors in relation to the planes of the head are most important in case analysis. His figures give the inclination of the upper central incisors to the F.H. Plane as a mean of 111 deg. for normal occlusions and only 118 deg. in Class II malocclusions.

Plaster models were X-rayed in a study by Steadman (38) and measurements were made on tracings of:

A. Overbites: these measurements varied between 0.5mm to 4.3mm with a mean of 3.1 mm.

B. Overjets varied from 0.0mm to 3.7 mm with a mean of 1.6 mm.

No correlation was obvious between the overjet and overbite. These measurements and also the inclinations of the upper and lower teeth are illustrated in the following diagram.

Measurements made on tracings of lateral head X-rays yielded the following relations.
This short paper by Steadman gives some further insight into the relationship of the anterior teeth to each other and to the floor of the nose and the mandibular border. Although these measurements are taken from acceptable occlusions, the large deviations from the means are evidence of the variations in relationships present even in good occlusions.

The aim of the study by Gilmore (39) was to investigate the relative relationship of the mandible to the cranium and the location of the mandibular first permanent molar within the mandible in adult males and females in both excellent occlusions and in Class II Division I malocclusions. Gilmore found a significant difference between the effective mandibular length in the two types of occlusions compared. The mandible was shorter in Class II Division I than in excellent occlusions both within the same sex group and between sex groups. The critical ratio of this difference was greater in females than males.

S-N length was found to be constant between the two groups of occlusion so that smaller facial size could not nullify the findings. S-N length was smaller in females in each type of occlusion owing to their smaller build.

The antero-posterior position of gonion is not significantly different within the sex groups or between the sex groups when comparisons are made between the groups studied. The angle N-S-Gm is not a valid means of measuring the antero-posterior position of gnathion. Gonial angle was practically the same in the two occlusion groups.

Considerable variations were found in relation of mandibular first permanent molars to mandible even when Elman's method of analysis was used.
Craig (40) undertook to find out what differences existed between the overall composite patterns of two groups of individuals of the same age, one group of which exhibited Class I and the other Class II Division I malocclusion. Craig made composite tracings from lateral head plate X-rays of male and female Class I and Class II Division I patterns and superimposed these two tracings. Composite patterns were also made and superimposed of the male and of the female patterns in these two classes of malocclusion. When the composites of both male and female were superimposed anatomical points in the cranial base and maxilla were found to be closely comparable.

However the body of the mandible large variations were evident between the two types of malocclusion and were large enough to be considered significant.

The points representing the anterior surface of Class II Division I, mandible fell 4–5 mm posterior to the corresponding points of the Class I mandible as also did the incisors and mandibular first molars.

The groups of males and females compared separately showed the same result. Craig reaches the conclusion that the basic reason for the molar relationship in the Class II Division I malocclusions lies in the fact that the mandibular body is shorter in these cases than in Class I. However he qualifies his statement and says that this represents only the mean or average picture which is made up of a large number of variations in size.

It is the combination of the two factors of wide individual variations in parts and the tendency for a difference in mandibular body length between the classes of malocclusion here studied which is responsible for many of the controversies in the assessment of skeletal dysplasia.
In this cephalometric study by Baldridge (41) of Class I, Class II Division 1, Class II Division 2 the position of the maxillary first permanent molar and the point gnathion in relation to the face and cranium were measured by angles.

1. Angle N-S -6 Masion, sella turcica, maxillary first permanent molars.

Baldridge's findings suggest that the gnathion bears the same relative position to the cranium in Class I and Class II Division 2 but the gnathion is slightly more posterior in Class II Division 1. The angle N-S-6 is practically constant in the three groups and this supports Angle's contention that the maxillary first permanent molar assumes the same relation to the face and cranium in various classes of malocclusion. Baldridge's findings also show that in Class II Division 1 the mandible is in a posterior position to the cranium.

From these studies of Adams, Elman and Waldridge we find the following facts. The mandible is the same overall size in Class I and Class II malocclusions, the gonial angle is the same and the first molars show the same relation in both malocclusions.

Therefore if the mandible is distal in Class II Division 1 as Baldridge says the fault must lie in the posterior position.
of the joint in the temporal bone.

A study of the facial pattern associated with Class I and Class II Division I and Class II Division II was undertaken by E.W. Renfroe, (48).

Renfroe studied 93 cases, Class I (43 cases) Class II Division I (36) Class II Division II (16) and angular readings were made from the tracings.

Nineteen angles were read and tabulated and a mean worked out for each type of malocclusion from which using an arbitrary S-N line the following composite tracing was developed.

Renfroe's conclusions when taken together with those of Adams, Ellman and Baldridge would seem to make obvious

1. The Class II mandible of both divisions are not characterised by lack of development.

2. The maxillary first permanent molar instead of being anterior to its normal position has a tendency to lie slightly posteriorly.

3. Class II is characterised by a posterior position of the mandible as maintained by Angle.

4. The angle of the mandible is greater in Class I than
in Class II of either division.

5. The chin point in Class II Division 2 is about as far forward as Class I owing to the square type of jaw in Class II Division 2.

In his previous article in 1941, Baldridge (42) concludes that the upper first permanent molars assume the same definite relation to the face and cranium in both Class I and Class II malocclusions. This verifies the basis of Angle's classification.

Elsasser and Wylie assert that the upper first permanent molar is further forward in relation to the cranium in Class II Division I cases but according to Baldridge they deduced this from the angular relation N-S-6. As the difference in the reading of this angle between the two groups is only 0.11 of a degree, Baldridge rightly asserts that this is not proof. In this study Baldridge restudies the X-rays used in his previous work.

Points and lines and angles used are shown below.
Using in this study the angular measurement S-6 to Frankfort Horizontal the relation of the upper first permanent molar to the faceal and the cranium would seem to be the same in Class I and Class II malocclusions.

The findings on the linear measurement from point A to the mesial of the upper first permanent molar would seem to indicate that a difference is found between age groups with a larger measurement being found in a younger age group.

In a cephalometric study Drellich (43) has measured 28 variables in normal occlusion and in Class II Division I malocclusions. In most of the variables studied those of the malocclusion showed wider standard deviations, hence Drellich infers that Class II Division I malocclusions show more variability in the facial pattern.

Pairs of means which differed significantly include the following

1. Relations of the face as a unit
2. Ratios of the dimensions of the face
3. Relations of planes of the face
4. Relations of the dental arches and dental units.

In this study Drellich uses only 24 cases of malocclusion and 24 cases in his control group. In consider that this is a much too small sample from which to make statistical deductions. However as his deductions are all rather obvious and not contentious he apparently considers his group large enough to produce statistical results.

Nelson and Migley (44) used 250 standardised lateral X-rays in their investigation and comparison of the dimensions of mandibular basal bone. These two measurements were made as depicted below.
Total length of mandibular basal bone.

Length of mandibular basal bone supporting alveolar bone and teeth.
The data obtained shows a greater length of mandibular basal bone in normal and Class I occlusions than in Class II Division I but only to the extent of a mean reading of 2.8 mm which does not seem significant. Maximum and minimum values however in each group show a difference of 10 mm, the Class II Division I cases being the smaller which might still indicate a deficiency in the basal bone or basal bone growth in some of the Class II Division I cases although the mean readings of all cases studied are about the same. As a single factor however mandibular basal bone length would not seem to be extremely important in a very high percentage of Class II Division I malocclusions.

Blair (45) used 100 subjects between ten and fourteen years in his cephalometric study of Class I, Class II Division I and Class II Division 2 malocclusions. The points and planes used are illustrated below.

Blair prefacing his findings with the very wise statement that conclusions drawn from the examination of mean data should be tempered by the concept of individual variation and that in his findings only mean values are involved. In conflict with previous studies Blair finds that the mean pattern of male and female within each class of malocclusion
varied only in absolute size.
Blair's data does not support the contention of a posterior positioning of the body of the mandible in Class II Division 1 cases. However a decreased effective length of the mandible was found in Class II Division 1 cases.
The gonial angle in Class II Division 2 cases was significantly less than in Class I cases. Blair states that a high degree of variability of facial skeletal pattern can be seen within each class of malocclusion studied but between classes only minor differences were found in the means.
Most of these cephalometric appraisals seem to conflict in their findings in one way or another and while some of this conflict may be caused by different sampling by investigators Blair, I think, raises a very potent reason for it in the statement that a classification of malocclusion based on tooth relationship may not divide the sample into groups of equally well defined or characteristic skeletal patterns as has been assumed in the past.
Finally Blair finds that the lower first permanent molar does not maintain a constant relationship to the body and ramus throughout the growth period, however no differences were noted in its position in the different class of malocclusion studied.

Most recent studies of Class III etiology seem to confirm the fact that this particular type of malocclusion is due to a disturbance of the normal growth pattern in the early stages of differentiation.

(46) Shoemetzer observed that the position of the maxillary first permanent molar in Class III malocclusions is typical of this class and is situated slightly further forward than in Class I and Class II malocclusions in relation to the cranial base planes. The mandibular molar in its position is also typical for Class III malocclusions and different in its relation to the mandible than in either Class I or Class II malocclusions. The height of the mandible is greater at the symphysis and less at the molar region in Class III malocclusions than in Classes
William C. Staph (47) made a cephalometric roentgenographic appraisal of the facial pattern in Class III malocclusions. The typical tracing made is shown in the accompanying reproduction with the points selected and the planes constructed for use in the study.

Staph concludes that Class III malocclusions arise rather from a continuation of growth beyond the normal than from an alteration in the growth pattern. He remarks in his study on the regularity of the points gonion, gnathion, the parallelism of the lower borders of the mandibles, the almost parallel nasal floors and the constant height, between Class III and normal occlusion. All Class III malocclusions have distinguishing facial pattern and these appear to be independent of sex or age.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Angle E.H.</td>
<td>Malocclusion of the teeth.</td>
<td>1907.</td>
</tr>
</tbody>
</table>


42. Baldridge J.P. Further studies of the relation of the maxillary first permanent molars to the face in Class I and Class II malocclusions. Angle Ortho. Jan 1950. 20:5.


AETIOLOGY.

This article by Brodie (I) and the one following by Wylie were presented at the same time and both are very good summaries of the number and complexity of factors with which we are faced in tracing the aetiology of certain abnormalities of the face and jaws. Brodie throughout his article emphasises the matter of variation and
ions and warns us not to place too much trust in norms and classifications.

While statistics are very valuable when applied to a group we must be cautious when applying statistical methods or data in the case of the individual. Any mean value is only as valuable as the size of the standard deviation or the smallness of the coefficient of variation.

As orthodontic diagnosis is largely a study in the size, relation and placement of anatomical parts many attempts have been made to establish a certain base of reference from which deviations could be evaluated.

The maxillary first permanent molar of Angle, the lower incisor axial inclination of Tweed, the Frankfort horizontal plane, Simon's orbital plane, and the Bolton plane of Broadbent have all been put forward at various times and of these probably the position of the maxillary first permanent molars is the most stable.

Edward H. Angle gave his law of classification which raised the study of orthodontics to the status of a science. However he was aware of the limitations of his hypothesis of the stability of the first permanent molar.

"The fact that the upper first molar varies considerably mesially or distally as to its location in different individuals which is always noted in anything like an extensive study of the subject, has led superficial students to regard these positions as normal, taken by chance, and out of harmony with other principles in the anatomy of individuals, but in reality these variations are to be expected and are necessary in the creation of different types and different individuals.

We know that while all human faces are greatly alike, yet that all differ. Lines and rules for their measurements have been sought by artists and many have been the plans for determining some basic line or principle from which to detect variation from the normal, but no line, no measurement, admits of anything nearly like universal application."
Another method of appraisal is that of typing and this means seems to be of little value.

The parts of the face may be divided into functional units. Thus we have the part concerned with respiration, the part concerned with sight and the jaws and teeth concerned with mastication to the greatest extent perhaps, but also with other functions.

These parts and their constituent bones may vary according to hereditary, functional and environmental influences. They may also vary in harmonious or inharmonious fashion and thus we can realise the explanation of the wide divergence we see in the form of the human face.

Brodie pleads for the abandonment of the norm concept because we cannot assess a malocclusion in the individual by comparing his case with the pattern arrived at by averaging large numbers of different individuals.

To quote Brodie: - "The individual carries with him the answer to his own treatment."

While we have a range of variation in every component part of the face we must also have a variation in the adjustments of one part to another.

These zones might be anterior cranial base to upper face; floor of nose to maxillary alveolar process and teeth; mandible to maxilla; and mandibular alveolar process and teeth to body of mandible.

All of the variations mentioned so far are skeletal dysplasias over which we have no control and in which teeth are the passive victims of circumstances. Then in addition we have the distortions produced by a malrelation of teeth.

Here we have the problem of the adequacy of the jaws to accommodate the teeth without crowding.

We have variables such as the size of the jaws and the teeth, the time and rate of growth and the order and time factors of eruption. In some cases we may not find the answer to the problem of whether the teeth will all be accommodated without crowding until past the twenty-first year when growth ceased.

All the above variables may be harmonious or inharmonious
with resultant good or ill-effects.
One important point to remember is that the teeth will never
grow larger but the jaws are almost certain to.
Another system of variables and most important is that of the
musculature. The tongue and muscles of the face have an im-
portant moulding effect on the alveolar bone and teeth and
once more we have factors of size, position, growth to contend
with in the production of variations.
There is an antagonistic relation between the tongue on the
inside and the lips and cheeks on the outside that determines
largely the inclination and position of the alveolar process-
es and teeth except in cases where maleruption, slow growth
or occlusal interferences can be shown.
It would appear that everything we can measure is variant and
that we can expect any conceivable combination or have to deal
with the permutations of a countless number of values.
The teeth are more or less passive and are at the mercy of the
behaviour of the parts around them.
Malocclusion of the teeth therefore with the exception of
that traceable to local environmental factors becomes the vis-
ible symptoms of inharmonious relations of adjacent parts or
parts at a distance.
This is a bleak outlook but there is one bright spark, and
that is the knowledge that growth patterns do not change.
What we are confronted with in the individual cannot get worse
and with an ally of continued growth to rely on, proper treat-
ment may lead to a marked improvement.
Brodie emphasises that we must abandon the idea of a normal
occlusion concept and that we should stop comparing every
face we see with some mental image that is pleasing to us
and that has been set up by the compilation of a group of
averages. Instead it appears that we must attempt to estab-
lish the growth pattern of the individual and try to determine
the course of development of his face and teeth and predict
its ultimate potential.
In his review of theories of malocclusion, Wylie (2) emphasises the fact that orthodontia is a study in morphology and morphology depends on relationships. The relationship of the various tissues and parts which make up the human face and the anatomy of the jaws may vary a great deal. Variations in one part may be compensated by variation in another or two extremes of variations may reinforce one another to produce a result of severe distortion of cranio-facial pattern. Dysplasia is defined as the illogical inclusion of parts not well matched up with the rest of the body. In a study of dysplasia Sheldon found it to be more prevalent in the head and neck areas than in any other part of the body. As evidence of the disproportion of relationship, Wylie quotes Stockard's experiments on dogs in which he not only found disharmony in the crossbred dogs but also in the pure strains whose antecedents had been carefully controlled for generations. Hellman and Wylie himself, in studies emphasised the disproportion of adjacent parts in normal occlusions and in comparisons of parents and offspring. As regards the comparisons of teeth and facial bones J. Leon Williams despite artificial tooth manufacturers' advertisements contradicted his earlier findings and stated in no uncertain terms that teeth form and facial form bear no correlation.

Wylie discussed two facts in his article.

**Fact 1. THE MORPHOGENETIC PATTERN OF THE HUMAN FACE IS LAID DOWN AT BIRTH AND THEREAFTER DOES NOT CHANGE.**

The work of Brodie forces us to discard a lot of theories of aetiology which depended on the notions of some disruption of growth of the child. New explanations must be found for all malrelationships which are the result of disproportions between facial parts, such as Class II, Class III, closed and open bites.

The pattern of growth remains the same whether growth be normal or diminished due to some post-natal cause.
Fact 2. Malocclusion is primarily a morphological problem, and it demands that the orthodontist creates the most harmonious set of relationships possible out of conditions which were originally disharmonious.

A. Relationship of teeth of one arch, one to another. Dysplasias in these cases are not obvious.

B. The relationship between the teeth of one arch and those of the other.

Mesio-distal width of each arch is a problem especially when teeth in one arch are congenitally missing.

C. The relationships between the mandibular bony base and the maxillary bony base.

The size of each base compared with the other is the problem in this relationship which includes the Class II and Class III malocclusions.

D. The relationship between dental arches and their respective bases.

Wylie says this issue will never be settled because it involves aesthetic judgements which are purely subjective.

Wylie says that most of our problems arise through the chance combination of various facial components in such a way that a truly harmonious arrangement between them is the exception rather than the rule.

Teeth of each arch are of different size to opponents in the other arch which makes the mechanical interdigitations of the teeth a complex problem.

Any disproportion of the bases which support the teeth is immediately shown by the disturbances in the occlusal arrangement. To quote Wylie "Treatment planning sometimes called diagnosis, will increase in effectiveness as orthodontists build treatment planning more around their concept of what they think treatment can accomplish, and less around what they fancy was originally the cause of the malocclusion."

Wylie urges the importance of inheritance as a factor and an important one in orthodontic problems.

He denies that malocclusion is a malady and could not even be
described as a malformation but rather as a disproportion of the facial parts.

Infinite variety is a fundamental fact of nature and the attainment of this variety has been achieved by nature by the random assembly of the facio-dental parts with little regard for how they will go together.

E.A. Hooten (3) in an article describes the evolutionary trend in the human face with particular reference to malocclusions and dental caries.

He contends that the three main races of mankind, Negroid, Mongolian and White have all been affected by malocclusion and dental caries, the White race to the greatest extent and the Negroid race the least.

Both became more noticeable as civilisation progressed in each race. In the white race with the formation of a great civilisation in the Nile valley about 3,000 B.C. degeneration of the occlusion began.

CAUSES OF FACIAL RETROGRESSION

Hooten advances as possible causes:

1. The lack of natural selection in extinction of extremes as in a civilised community the factor of survival of the fittest does not hold good altogether.

2. Inbreeding has accentuated the maldevelopment of the parts of the face.

3. Atrophy of function of the masticatory apparatus arising from dependence on soft cooked foods.

4. Abnormal bone development due to deficient diet.

It is difficult to eliminate retrogressive hereditary factors unless by selective breeding.

Functional atrophy affects adversely the different parts in the order of their comparative plasticity. Thus in the face the muscles are affected first, then the bony jaws, and lastly the teeth.

Leigh C. Fairbank (4) in an analysis of some of the research in growth and development as affecting etiology names the
three factors in growth and development as hereditary, environment and function. His article mainly consists of extracts and findings from the works of A. LeRoy Johnson, Sicher, Brodie, Hellman and Hays Nance and he summarises the findings of these men as follows.

1. There is no interstitial growth
2. Hereditary and environment never operate alone and these must be in perfect balance for normal occlusion to result.
3. Growth of bone in mandible and maxilla is one of the forces of eruption.
4. Dr. Angle's concept of the integrity of thirty two teeth must be discarded.
5. No growth takes place in the body of the mandible mesial to the first permanent molar subsequent to its eruption.
6. Stability of the denture is dependent on its being positioned over basal bone.
Salzmann divides the aetiological factors in malocclusion into two periods and six factors. These are illustrated diagrammatically and the interaction and interdependence of these factors is emphasised.

1. **FRENATAL**

A. Genetic or Hereditary

Genetic abnormalities may be morphological, physiological, pathological and psychological in character. They may be either in evidence at birth or may manifest themselves later in life. They may assume the characteristic of either parent or a mixture of the two or they may originate from some distant ancestor.

Although some, including E.H. Angle have denied inheritance as a cause of occlusal abnormalities most writers on the subject emphasise the part hereditary plays in the pattern of the face and hence the jaws and teeth.

There is a high correlation between parents and children for a number of facial dimensions.

Salzmann lists malocclusion which may have a genetic origin.

1. Prognathism
2. Extreme micromandibular development
3. Bimaxillary protrusions
4. Bimaxillary atresia (small mouth and undeveloped arches)
5. Teeth of extraordinary large size and abnormally small jaws or vice versa.
6. Hypoplasia and discoloration of teeth
7. Peculiarities of the number and arrangement of the teeth.
8. Facial clefts, cleft lip and cleft palate
10. Characteristic crowding of the teeth with rotation and ectopic eruption of certain teeth, notably the maxillary canine in cases where deciduous teeth have not been extracted too early.
11. High palate associated with extremely narrow face and head.

B. DIFFERENTIATIVE
   1. General
   The failure of the embryo to undergo normal morphological differentiation may result in development deficiencies and abnormalities of the mouth, tooth eruption, cleft palate, and lip and other dento-facial anomalies.
   2. Local
   Anomalies of the morphological differentiation of all or part of the face, jaws and tooth germs may occur.

C. CONGENITAL
   A congenital condition is one which present at birth and has no other significance and may congenital deformities are a result of hereditary.
   Salzmann classifies congenital abnormalities as follows:
   1. General
      (a) Abnormal state of mother during pregnancy, malnutrition, endocrine disturbances, infectious diseases, syphilis.
      (b) Metabolic and nutritional disturbances of
foetus.
(c) Accidents of pregnancy and childbirth, intra-
uterine pressure or accidental traumatisation of the
foetus by external factors.

2. Local
(a) Abnormalities of development of the jaws
(b) Abnormalities of development and growth of oral
organs and structures including the tooth germs.
(c) Trauma, pressure, accidents affecting jaws and teeth.

A. DEVELOPMENTAL

1. General
(a) Birth injuries
(b) Abnormalities of relative rate of growth in different
body organs.
(c) Hypo - or hypertonicity of muscles which may ultim-
ately affect dento-facial development.
(d) Endocrine disturbances which may modify the growth
pattern.
(e) Nutritional disturbances
(f) Diseases which affect the growth pattern.
(g) Allergy

2. Local
(a) Abnormalities of dento-facial growth
1. Birth injuries to head, face and jaws.
2. Micro or macrognathia
3. Micro - or macroglossia
4. Abnormal frenum labii
5. Facial haemiatrophy
(b) Anomalies of tooth development
1. Delayed or premature eruption of deciduous
or permanent teeth.
2. Delayed or premature shedding of deciduous
teeth.
3. Ectopic eruption
B. FUNCTIONAL FACTORS

1. General
   (a) Muscular hypotonicity
   (b) Endocrine disturbances
   (c) Neurotrophic disturbances
   (d) Nutritional deficiencies
   (e) Postural defects
   (f) Respiratory disturbances, mouth breathing

2. Local
   (a) Perversion of forces exerted by inclined planes of teeth
   (b) Loss of force exerted by proximal contact of teeth.
   (c) Temporo-mandibular joint disturbances
   (d) Masticatory and facial muscular insufficiency or hyperactivity
   (e) Insufficient masticatory function especially during tooth eruption period.

C. ENVIRONMENTAL OR ACQUIRED

1. General
   (a) Disease may affect the dento-facial tissues
   (b) Nutritional disturbances
   (c) Endocrines in childhood and later in life
   (d) Allergy
   (e) Trauma and accidental injuries

2. Local
   (a) Forces of occlusion
   (b) Too early extraction of deciduous teeth
   (c) Too long retention of deciduous teeth
   (d) Delayed eruption of permanent teeth
   (e) Loss of permanent teeth
   (f) Disease
   (g) Temporo-mandibular disturbances
   (h) Infections of the gums
   (i) Pressure habits
   (j) Traumatic injuries - jaw fractures.
Dowel (5) writes a good article on the labial frenum and its role in the etiology of malocclusion which he says is grossly overrated.

The differential diagnosis between the genuine but rare abnormal frenum, and the harmless, though common, enlarged frenum has never been adequately explained.

Separation of the teeth cannot be regarded as a symptom of abnormality but is a most common characteristic of the developing mouth and often has disappeared in adulthood.

Neither is the frenum necessarily the cause of the separation. Careful diagnosis over a period of months should precede resection of the frenum.

DEVELOPMENT OF THE NORMAL FRENUM

Early in foetal life it is a relatively passive structure, dividing the dental arch into two lateral portions and with distinct attachment to the palatine papilla. Alveolar growth exceeds that of the frenum so that by birth it has been expelled outwards to a superficial attachment on the crest of the alveolar arch. Recessive development tendency continues with the eruption of the deciduous teeth. With the eruption of the permanent dentition the structure should assume a normal position and attachment well above the interproximal gum tissue.

Centrals are separated in their crypts by a bony suture so must erupt spaced, which favours the presence of the frenum. Low attachment frenum will not be affected until the eruption of the laterals and cuspids.

Frenum should not be resected until cuspids have erupted unless absolutely necessary.

FACTORs IN VARIATIONS OF THE NORMAL FRENUM

The question is whether enlargement of frenum is the cause or effect of separated incisors. Atrophy of the enlarged frenum can be expected to take place naturally with the eruption of the teeth.

Malocclusion associated with the separation of the centrals should be treated as an orthodontic condition.
UNFAVOURABLE FACTORS IN RESECTION

Formation of resistant scar tissue and severance of trans-epithelial fibres of periodontal membrane. In most cases resection is not necessary and space may have a better chance of closing without operations.

THE NORMAL PRENUM AND ITS VARIATIONS

Normally, thin, triangular, knife-edge fold of mucous membrane which varies in form, size and position.

ACTUAL CAUSES OF SEPARATION OF THE CENTRAL INCISORS

1. Arch greater than mesio-distal diameters of teeth in which frenum is the result not the cause.
2. Habits, tongue thrusting, and thumb sucking.
3. Bad lip habits - lack of function of upper lip allows anteriors to drift forward.
4. Peg like laterals
5. Absence of laterals - Dewell suggests moving canines into lateral positions and the rest of posteriors forward to a Class II relation. Also admits filling gap with artificial teeth. The frenum persists simply because teeth in mal-occlusion do not exert the correct pressure to atrophy it.

DIAGNOSTIC SYMPTOMS OF AUTHENTIC ABNORMALITY OF THE PRENUM

Markedly enlarged, and retaining in exaggerated form most of the coarsened and thickened characteristics of its earliest developmental stages. Presents a wide fan-shaped attachment to the upper lip which tapers downward to a distinct sheet like process extending between the central incisors to a definite union with the palatine papilla. Seems to become more pronounced with increase in age. Distend upper lip outward and upward and if this produces blanching and a definite amount of movement of the tissues between the incisors and also the palatine papilla, the frenum may be considered abnormal.
APPLIANCE CONSIDERATIONS

An appliance is necessary and must be promptly used after resection to close the space with minimum formation of scar tissue.

SUMMARY

1. There are two different and confusing deviations from normal; simple harmless enlargement and true abnormality.

2. No frenum should be considered abnormal until every conceivable cause of the separation of the incisors has been eliminated.

3. The frenum develops in foetus and then atrophies throughout life to adulthood.

4. Centrals erupt separated and may remain so until cuspids erupt.

5. Protracted presence of separation favours existence of frenum. Abnormalities of surrounding tissues encourage separation.

6. Resection provides no assurance that centrals will move together.

7. In doubtful cases, orthodontic appliances should be placed to close the gap before surgery is attempted. If appliance is unsuccessful resection may be carried out and appliance is then ready in place to move the incisors so as to minimise formation of scar tissue.
This investigation by Subtelney (6) studied four areas. 

1. Location and configuration of adenoid tissue 
2. Growth of the adenoid tissue and contiguous structures. 
3. Changes resulting from removal of adenoid tissue. 

**METHODS**

Cephalometric X-rays and cephalometric laminography were employed in this study.

Serial tracings of cephalometric headplates revealing changes in the adenoid tissue mass with age. The stippled area represents adenoid tissue as well as the soft tissue underlying the roof of the nasopharynx.

Serial tracings revealing changing relationships with growth, between adenoid tissue and contiguous structures.
Serial tracings depicting an over-abundant development of adenoid tissue. Note the change in positional relationships between the tongue and soft palate.

Serial tracings revealing the upward and backward regression of adenoid tissue after its peak of growth is reached. Age 14 represents the peak of adenoid growth in this individual.
Serial tracings representing the full growth cycle of adenoid tissue. Growth to maximum bulk and subsequent atrophy is evident.

The distance between the superior surface of the soft palate and the inferior surface of the adenoid tissue appears quite adequate for naso-respiratory needs.

Residual adenoid tissue is evident in the anterior region of the nasopharynx. The airway passage is not markedly improved.
1. Location
The adenoid tissue is located in the naso-pharynx or above the level of the soft palate.

2. Growth of adenoid tissue and surrounding structures
Adenoid tissue shows a specific cycle of growth. It does not become evident radiographically until the age of six months to one year. From this stage growth is rapid to two to three years of age when it may occupy as much as half of the naso-pharyngeal cavity. Growth continues but at a retarded rate until its greatest bulk is attained about ten to eleven years of age or as late as fourteen to fifteen years of age.
Although this adenoid tissue is growing the cavity which encloses it is also growing continually and changing in shape. A stable relationship of growth exists between the posterior nasal spine of the palate and the anterior arch of the atlas from the second year onwards and there are indications that the width of the naso-pharynx stabilises at an early age.

The vertical growth of the naso-pharynx continues until the seventeenth or eighteenth year when maxillary growth ceases. Thus a state of equilibrium seems to exist, for although the adenoid tissue is growing rapidly, so also is the bone around growing in the three dimensions of space. This balance should exist until the peak of adenoid development is reached.
Before the peak is reached there may be a disturbance in this delicate balance if the adenoid tissue develops at a faster rate due maybe to excessive growth, allergic reaction, or reaction to infectious agents. This will cause an approximation of the adenoid tissue to the superior surface of the soft palate and a blockage of the naso-pharyngeal cavity.
After the peak of adenoid growth, the process changes to one of atrophy and by adulthood the tissue has completely atrophied and the greatest airway space is established.
Marked improvement in the nasorespiratory passage as a result of adequate removal of adenoid tissue. The tissue was removed, upon recommendation, during orthodontic treatment. Note the change in spatial relationship between the tongue and soft palate.

A. Excessive adenoid tissue causing an aberrant tongue-soft palate relationship. The posterior dorsum of the tongue appears to in a downward and forward position away from the soft palate.
B. Improved tongue position resulting from the provision of an adequate nasorespiratory channel. Note that some residual tissue still remains.
3. **CHANGES RESULTING FROM REMOVAL**

Complete removal of adenoid tissue results in a considerable improvement in the airway space in the naso-pharyngeal region but incomplete or partial removal will not necessarily produce any improvement.

In cases of excessive adenoid growth with mouth breathing the tongue is changed from its normal rest position along the palate. This is to provide an oral airway. The writer remarks that in cases of removal of adenoids the tongue has been noticed to resume its normal relationship and hence its deleterious pressure on the teeth has ceased.

**ORTHODONTIC IMPLICATIONS**

Effects of an enlarged or abnormal adenoid tissue may be a contributing factor to a malocclusion.

Blockage of normal respiratory channels with accompanying mouth breathing produces detrimental pressure from the tongue and lack of influence from the lip and associated musculature. With the drop in position of the tongue the unopposed buccal musculature will have the effect of narrowing the maxillary arch. Subtelney emphasises that not all children with enlarged tonsil and adenoid tissue will be mouth breathers. Also that although most children who are mouth breathers would possibly outgrow the habit as the adenoid tissue atrophies by this time orthodontically the damage will have been done; therefore the child with a mouth breathing habit should be examined for the presence of adenoid tissue and the quantity and location of the tissue carefully evaluated. If the problem is coped with before the permanent teeth are positioned the prevention of an orthodontic problem is possible.

It would appear that the longer the habit is established and the greater the deterioration of tooth relationships the more difficult it becomes to produce a stable result by treatment even though the adenoid tissue has begun to atrophy.
Emslie, Massler and Zwemer (8) have contributed a most comprehensive article on the problem of mouth breathing. Mouth breathing may be defined as habitual respiration through the mouth instead of the nose. The tendency is very strong for nasal respiration which is the natural function as the passage of the air through the nasal passages cleans, warms and moistens it before it goes to the lungs. The etiology of the mouth breathing may be said to be an anatomical predisposition of narrow nasal passages plus nasal obstruction. Mouth breathing occurs mainly in the dolicho-facial slender type.

**PREDISPOSING FACTOR**

Narrow nasal passages

Exciting factor.

Nasal or pharyngeal obstructions

1. Engorged turbinates especially in presence of
   (a) Deviation of septum
   (b) Allergies
   (c) Climatic conditions. Hot dry air and also dirty air.
   (d) Chronic Rhinitis and sinusitis

2. Adenoids
   Normally large from two to six years but thereafter diminish and by adolescence they have been reduced to much smaller adult dimensions.
   Many instances of obstructive mouth breathing may be self-corrected during adolescence.

There are typical "adenoid facies"

3. Deviated Nasal Septum
   Severe deviations due to injury diminish size of airway.

4. Nasal Polyps - surgical removal is essential

5. Atrophic Rhinitis.

PERPETUATING FACTOR (HABIT)

1. Residual Habit
   Habit may persist after obstruction is removed
   Mouth-screen after adenoidectomy is recommended

2. Imitation

3. Open mouth habit, although open mouth children do
   not necessarily breathe through mouth.

4. Dorsal head sleeping position may serve to perpet-
   uate a mouth breathing habit and a Class II relation
   of the mandible.

THE EFFECTS OF MOUTH BREATHING ON THE RESPIRATORY SYSTEM

1. Nose and paranasal sinuses
   The evidence of the above effects seems to be contrad-
   ictory and as the writers of this article say "it is
   not known up to this time what comes first, the
   rhinitis or the mouth breathing."

2. Lower Respiratory Tract.
   Probably the habit predisposes to bronchitis.

EFFECTS OF MOUTH BREATHING ON THE ORAL STRUCTURES.

1. Gingivitis
   Mouth breathing is an important factor in the prod-
   uction of gingivitis which usually in the form of a
   pronounced tendency to hypertrophy or hypoplasia.

2. Periodontal disease.

3. Coated tongue

4. Dental caries.
   No controlled studies are reported but it has been often
   suggested that the habit increases susceptibility to caries.

TREATMENT

Oral screen at night
Taping mouth

EFFECTS OF MOUTH BREATHING ON THE GROWTH OF THE FACE

Lack of tone in lips with shortening of upper and heaviness
of lower which generally lies beneath upper incisors.
Tongue action on palate is missing and buccal segments are
constricted by the buccal muscles.
Maxillary arch and maxilla become V-shaped and palate seems high. Maxillary sinuses and nasal cavity frequently become narrowed with narrowing of face.

MALOCCLUSION OF THE TEETH

There are two schools of thought regarding mouth breathing as a factor in the etiology of malocclusion.

1. Changes in muscular balance while the mouth is held open is a primary factor in the development of typical Class II Division I type of malocclusion.

2. Other view is that the malocclusion is not the result of the mouth breathing but the result of genetic factors and is characteristic of that individual and his facial type.

MOUTH BREATHING, MALOCCLUSION AND FACIAL TYPE

These two views can be reconciled on the basis that mouth breathing is injurious only to narrow facial individuals whose already narrow arches may be further constricted by the habit. In broad faced individuals mouth breathing would have little or no effect.

SUMMARY

Recent observations suggest that too much importance has been attached to mouth breathing per se as an etiological factor in maldevelopment of the face and jaws and malocclusion of the teeth and not enough to the predisposing genetic factors.
Gerry and Sangston (7) carried out an investigation on congenital mandibular deformities in new born infants and established the following facts.

Congenital mandibular deformities in new born infants have been frequently found, but infrequently described.

Of sixty new born infants in a month, twelve had deviated mandibles.

All deliveries were normal, but a deviation from the horizontal to the right or left was found.

In all cases a hand or foot could be placed in juxtaposition to the indented effect.

These deviations seem to be due to intra-uterine pressure and not genetic disturbances.

Positions of comfort are maintained during the latter months of pregnancy and cause the deviations.

Thus when deviation of a jaw is present it may be accompanied by congenital dislocation of the hips.

No treatment seemed necessary for the twelve babies except that they should sleep on their backs for the first twelve months so as not to aggravate the condition.

Swinehart (9) in a case report gives details of malocclusion caused by the drug dilantin sodium which is used as an anti-convulsant in the treatment of epilepsy.

In about 50% of patients the drug causes a massive overgrowth of gum tissues. The teeth are moved labially and buccally by this gum hypertrophy with consequent spacing of the anteriors. Gum tissue may be removed by cautery and the teeth will return to normal but if dilantin therapy is continued the gums will hypertrophy again with a similar effect on the occlusion.