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A Mensural Assessment of the Interrelation of the Glenoid Fossa, the Curve of Spee, the Gonial Angle, Posterior Cusp Angulation, Overbite, and Overjet as Factors of Occlusion

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A MENSURAL ASSESSMENT OF THE INTERRELATION OF THE GLENOID FOSSA, THE CURVE OF SPEE, THE GONIAL ANGLE, POSTERIOR CUSP ANGULATION, OVERBITE, AND OVERJET AS FACTORS OF OCCLUSION

by

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AUTOBIOGRAPHY

Edwin C. Liedtke was born in Ackley, Iowa, on January 7, 1932. Elementary education took place in Iowa, Rock Island, Illinois, and Chicago, Illinois. He attended Fenger and Parker High Schools in Chicago and graduated in June 1948.

Predental studies were completed at North Central College, Naperville, Illinois, in June 1951, where he received a B.A. degree.

A Doctor of Dental Surgery degree was conferred upon him by Loyola University School of Dentistry in Chicago, Illinois, in June 1955.

Upon completion of Dental School, he served for three years in the United States Air Force. During his last two years of military service, he held the position of Base Dental Surgeon at Truax Field in Madison, Wisconsin. He was discharged in November 1958.

From January 1959 until June 1970, he maintained a practice of general dentistry in Downers Grove, Illinois, and also served as a part time instructor in Operative Dentistry at Loyola University School of

Dentistry. He taught in both a clinical and technique course capacity and eventually attained the rating of Assistant Professor in the Operative Department.

In June 1970, he entered graduate school at Loyola Dental School to pursue a specialty in Orthodontics and a M.S. degree in Oral Biology.

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INTRODUCTION AND STATEMENT OF THE PROBLEM

Introductory Remarks

Many studies illustrating positive interrelationships between the individual determinants of occlusion are presently available. However, there is no literature demonstrating a mensural roentgenological approach to the interdependence of the glenoid fossa, the Curve of Spee, and posterior cusp angulation. Updegrave (1951) correlated temporal mandibular joint roentgenography with clinical and other roentgenographic examinations. He believed this procedure would clarify controversies with undisputable radiographic evidence. Correlation of cephalometric with temporomandibular joint roentgenograms would help to verify an interrelationship (if one exists) between joint form and function with some of the classified types of occlusal relationships.

Statement of the Problem

This study is designed to provide additional pertinent information regarding possible interrelationships between various factors of occlusion from a given sample of dry skulls.

Cephalometric laminagraphy of the temporomandibular joint, Curve of Spee, gonial angle, and posterior cusp angulation will be employed. Occlusal classifications (by Angle) and overbite and overjet will be determined directly upon the same dry skulls utilizing measuring devices. The collected data will be analyzed statistically in order to ascertain the level of significance of the findings.

CHAPTER II

REVIEW OF THE LITERATURE

Although numerous works have been published on the variation of the individual factors of occlusion, a review of the pertinent literature has failed to provide evidence of studies correlating the interrelationships of the determinants of occlusion. The determinants of occlusion described by Guichet (1970), which are being investigated in this thesis are: I. The Character of the Protrusive Condylar Path which is undeniably dependent upon the Morphology of the Articular Eminence; II. The Protrusive Incisal Guidance Characteristics Relating to Overbite and Overjet of Anterior Teeth; III. Occlusal Plane Inclination or the Severity of the Curve of Spee; and IV. The Cuspal Angulation of the Posterior Teeth as Determinants of the Degree of Interdigitation of the Posterior Occlusion. The following review will be subdivided as indicated by the topic headings.

I. The Character of the Protrusive Condylar Path as Determined by the Articular Eminence.

A. Growth Patterns of the Temporomandibular Joint

Sicher and Weinmann (1955) stated that

increased function or physiologic stress within the normal limits of tolerance acts as a growth stimulus on bone. When this fact is applied to the temporomandibular joint of the maturing child, it would follow that a shallow glenoid fossa would be present until the age of eruption of the permanent dentition. The glenoid fossa deepens as the increased muscular force and function becomes apparent. The remodeling of the fossa and the lengthening of the anterior and posterior articular eminences are considered to be a normal skeletal response to increased physiological stress.

Moffett (1966) substantiated this growth sequence by a detailed study of the embryological and histological aspects of the temporomandibular joint, from embryo stage to the aged individual. His findings were based on dissection of human wet skulls of all age groups and illustrated remodeling and contour changes occured up to the fourth decade in the temporomandibular joint. Up to that time there is a gradual increase in the posterior slope of the anterior articular eminence and a corresponding increase in the depth of the glenoid fossa. These changes are regarded as normal growth processes. After age forty there is a tendency for the eminence to become flatter, expecially in those individuals who are edentulous. The condylar head also increases in contour up to age forty, but tends to flatten thereafter similar to those cases of younger patients who contract degenerative disease. Disc perforation usually is accompanied by flattening of the condyle immediate to the area of perforation.

B. Morphology

Ricketts (1950) completed a laminagraph study on clinical patients of the temporomandibular joint and a summary of the findings pertinent to this thesis is as follows:

1. There is a considerable variation between the size of the condyle and the size of the fossa. Some condyles appeared quite small for their respective fossa and others appeared too large.

2. The condyle in both Class I and Class II cases (Angle) tended to move forward of the tip of the eminentia articularis during wide opening movements. The main difference lay in the range of movement, that of Class II being slightly larger.

3. The relation of the condyle to the slope of the articular eminence was quite constant and it showed less variation than any other measurement. This was true in both Class I and Class II cases.

4. There exists quite a range of distance from the top of the condyle to the roof of the fossa. Class II cases tend to have the condylar head in a lower position in the fossa at rest position. When in centric no difference seemed to exist between Class I and Class II occlusions.

5. The slope of the posterior surface of the articular tubercle varied 50° in both Class I and Class II cases and no difference was discernable.

6. No relationship seemed to exist between the steepness of the condylar path and the type of occlusion when related to the occlusal plane.

7. Other than a high degree of variation, nothing significant was noted about the height of the eminentia articularis as related to Class I and Class II cases.

8. The roof of the glenoid fossa varied from 6 mm. above the Frankfort plane to 1 mm. below it. Class II cases seemed at a slightly lower level, but this group was younger.

9. Division 1 (Class II) showed a more posterior path of closure than Division 2; but Class II, Division 2, had a greater freeway space.

10. The mean values of the angle to the

eminence increased with age as the height of the eminence increased.

Emmering (1967) using cinefluorographic examinations of the temporomandibular joint found the main articulating or functional surfaces to be the posterior slope of the anterior inferior border of the glenoid fossa and the antero-superior surface of the condyle. Conventional radiographic evaluation was not precise, thereby necessitating cinefluorographic examination. Extreme variation in these articulating surfaces of the temporomandibular joint occurred. Four basic morphologic types were found.

1. 40% of the cases studied showed a condyle with superior surface flattened and an eminence in reverse image. (Type A Classification)

2. 42% of the cases showed a condyle with superior surface rounded with a radius greater than ½ the axial length and an eminence in reverse image. (Type B)

3. 11% of the cases showed a condyle with superior surface angled superiorly and an eminence in reverse image. (Type C)

4. 7% of the cases showed a condyle with superior surface rounded with the radius of curvature

near to ½ axial length and an eminence in mirror image. (Type D)

Bilateral symmetry was found to be most prevalent in the Type B condyle (30 cases); Type A was second with 19 cases.

Type A on one side was found with B on the other.

Type B on one side was found with C on the other.

Type A on one side was found with C on the other.

No Type A, B, or C plus D were found.

Bilateral symmetry of the inferior surfaces of the anterior articular eminentia were as follows: 72% symmetrical and 28% asymmetrical.

Type D condyle appears to be unable to function satisfactorily with an articular eminence of considerably less curvature.

Todd (1930) maintained that "form does not slavishly follow function." Angel (1948) stated, "Genes appear more important determinants than environment." These conclusions contradict the studies of Tomes and Dolomore (1901), Harris (1938), Breitner (1941), and Moses (1946) who all deduced that form and function generally speaking go hand in hand.

Reisner (1936) stated, "No correlation can be discovered between the type of occlusion and the slope of the posterior surface of the anterior articulating eminence which has frequently been claimed to exist."

Johnson (1964) correlated cross sectional area of the fossae and found them to correlate significantly. He also found that the breadth of the glenoid fossa is significantly narrower in children with Class II malocclusions than those in Class I types. However, no significant difference exists between the depth of the fossa and the slope of the inclination of the anterior articular eminence in either group.

Droll and Isaacson (1972) in their study relating glenoid fossa position and various skeletal discrepancies noted the glenoid fossa may be positioned too far anteriorly or posteriorly resulting in a disharmony between the maxilla and mandible even though both may be of the proper size. The vertical posterior of the glenoid fossa relative to the cranium may present the outward appearance of the mandible growing downward excessively or being excessively rotated as found in the studies of Bjork (1969).

Sarnat (1951), referring to Sicher's monograph, showed there to be a high degree of variation in the morphology of the anterior articular eminence. The degree of its convexity has a radius varying from 5 mm. to 15 mm.

C. Alteration of the Temporomandibular Joint Morphology during Treatment.

Breitner (1940) performed a series of experiments on Macacus rhesus monkeys in which typical methods of orthodontic treatment were employed, the changes noted clinically, and the animals subsequently sacrificed for histological study. Two standard methods of treatment of Class II malocclusions were used: one an outer maxillary pressure by means of rubber bands and the other, jumping the bite. In the histological study the alveolar bone surrounding the posterior teeth, the angle of the jaw, and the temporomandibular joint were studied. Changes were found in all of these regions to indicate, through the evidence of apposition and resorption, that the forces applied resulted not only in the mesial movement of the lower posterior teeth, but also a reorientation of the lower jaw and changes in the form and position of the condylar head and the glenoid fossa.

Because of the changes observed at the angle of the jaw and the temporomandibular joint, a method using bite planes and splints was introduced to correct cases of Class II malocclusion by means of forward movement of the mandible without movement of the teeth in the mesial direction from their alveoli.

Vaughn (1962) observed that the thickness of the mandibular joint tissue is influenced by the presence of teeth. His studies showed a thickening of the disc where function was removed as in edentulous cases. He also established the fact that the meniscus can respond to pressures, thickening when compressive or displacement forces diminish.

Through dissection of 250 condyles the average distance between condyle and fossa was 2.2 mm.

The disc thickness inversely varied as to amount of teeth in occlusion. Vaughn also concluded that the thickness of the disc is also influenced by:

1. The incline of the eminentia articularis.
2. The incline of the lateral section of the mandibular fossa.
3. The incisal relation of the anterior teeth.
4. The particular neuromuscular functional pattern of the muscles of mastication.
5. Direction of contraction of the external pterygoid muscles.

6. Medial displacement of the meniscus during function due to the direction of fibers and area of attachment.

These conclusions are supported by Sicher, Moffett, and others.

Haupl and Pransky (1939) found histological changes in the mandibular joint of an adult ape (pavan) after wearing a functional orthopedic appliance for eleven weeks. Considerable bone apposition was found in the glenoid fossa, the condyloid process, and at the site of the muscle attachments of the ramus and the area of the angle of the mandible.

Moss (1962), Breitner (1940), and Meach (1966) found evidence of positive changes in mandibular position in Class II cases treated with functional orthopedic appliances. These changes were due to condylar remodeling and apposition and a change in the fossa position when the condyle is repositioned.

Bjork (1951) and Jakobsson (1967) challenge this evidence and maintain these conclusions were reached as the result of alveolar bone repositioning.

Dubois (1966) observed condylar guidance changes may occur within the first 90 days after denture insertion. He concluded that the greater the discrepancy between the condylar guidance inclination of the articulator and the actual condyle of the patient, the greater will be an opposite change in the condylar path of the patient.

In order to effect a correct protrusion balance of the occlusion of complete dentures, it is required that the articulator condyles are of the correct condylar guidance inclinations.

II. <u>The Protrusive Incisal Guidance Characteristics Relating to Overbite and Overjet of Anterior Teeth.</u>

Guichet (1970) described incisal guidance as a reflection of the horizontal and vertical overlap of the anterior teeth. This fixed factor of occlusion also contributes to phonetic and esthetic values of the individual and can only be varied within narrow limits without having deleterious effects on a patient's speech and appearance.

Ramsford and Ash (1971) stated, "In a straight protrusive movement of the mandible, the degree of horizontal and vertical overlap, as well as the angulation and inclination of the anterior teeth, is related to the cuspal heights of the posterior teeth. The greater the horizontal overlap of the maxillary teeth, the shorter the posterior cusps must be to prevent posterior contact. Also, the greater the labial inclination of the maxillary incisors, the shorter the cusps of the posterior teeth must be to occlude in a harmonious manner, and in transversing the various protrusive and lateral excursions. Regarding the vertical overlap, the lesser the overlap, the shorter the posterior cusps should be." This is most pertinent in denture construction.

Bell (1960) studied two types of dentitions in the human and found each group to possess certain characteristics peculiar to that type being studied.

In the first group, the teeth had sharp cusps, deep overbite, extreme crowding, and limited lateral excursion. The glenoid fossae were deeper and constricted antero-posteriorly, and the articular eminentia were steeply inclined. These cases typified a vertical type of occlusion and contained thicker articular discs, suitable for this type of occlusion. The masticatory musculature also appeared to be weaker than normal.

In the second group, the teeth had flatter cusps, the arches were spacious and well rounded. Little crowding existed and lateral excursion was possible to a greater degree. These cases had shallower, more spacious fossae--antero-posteriorly, and discs of more uniform thickness. They appeared to be more horizontal in component and more capable of lateral and protrusive excursion.

Obviously all types of occlusions occur between these two extremes, and Bell recognized the fact that all factors of occlusion must be considered in a diagnosis of joint dysfunction.

Moyers (1963) describes excessive overbite as a combination of skeletal and dental features which causes an undue amount of vertical overlap in the incisor region. Excessive overbite is most commonly seen in Class I and Class II malocclusions, and a divergence of opinion exists as to what constitutes a normal range of overbite. Age, types of facial skeleton, and racial differences are some of the variations within the realm of overbite. Overbite may also be excessive if masticatory function is impeded, abnormal wear of teeth is induced, or the integrity of certain teeth is jeopardized by the failure of supporting structures.

The etiology of extreme overbite has the following factors to be considered:

1. Anterior face height, particularly the lower face.

2. Ramus height.

The above considerations refer to skeletal features. The following points deal with dental features:

1. Cusp Height.

2. Length and elevation of maxillary first molar.

3. Length of maxillary central incisor.

4. Length of mandibular central incisor.

5. Inter-incisal angle.

6. Position of maxillary first molar. If it tips mesially, the overbite deepens.

Salzman (1950) considered deep or excessive overbite one of the most common manifestations of malocclusion. Excessive overbite usually relates to the degree of vertical jaw development and the growth of the alveolar processes which occur at the time of eruption of the premolars and second molars. It is also inversely related to the degree of the forward growth of the mandible.

Orthodontically, in the absence of soft tissue (incisive papilla) irritation, treatment can be postponed until the premolars erupt. Perhaps the mandible growth at this time will decrease the overbite. However, in severe Class II cases treatment should be instituted during the eruption phase of the premolars as growth probably will be inadequate to correct the overbite severity. Vertical overbite presents the situation of preventing the shifting of the lower jaw when in molar centric relation without opening the jaw to an appreciable degree.

Bjork (1947) felt the main cause of excessive overbite was the relative length of the jaws to each other and that the occlusal changes were secondary.

He noted that a shortened facial height is common in persons with a deep overbite, accompanied with an approximation of the jaws causing a facial appearance of compression.

Hausser (1956) considered deep overbite to be of a dominant genetic origin. Depending on favorable or unfavorable environmental conditions, the anomally can express itself as true overbite or as maxillary dental protrusion; the inherent occlusal relationship being the deciding factor.

According to Baume (1950) the amount of the incisor overbite is determined primarily by the extent of mandibular growth (forward) during the eruption of the mandibular permanent incisors. Slight overbite in the deciduous dentition tends to increase slightly when replacement by permanent incisors occurs. A severe overbite in the deciduous dentition results in a worsened situation in the permanent incisors. Incisor overbite develops independently of molar occlusal adjustments.

The amount of overbite depends in part on the mesiodistal relationships of the dental arches. When the deciduous canines erupt, the overbite in the deciduous dentition is determined by the relationship of the maxilla to the mandible. Permanent incisor eruption is the determining period of the degree of overbite in the mixed dentition. Permanent premolar and canine eruption determine the amount of overbite in the permanent dentition.

Abnormal overjet may be due to maxillary protrusion (Class II malocclusion), retrusion of the mandible, retrusion of the mandibular incisors, or protrusion of the maxillary incisors.

Pragash and Margolis (1952) found excessive overbite associated with infraocclusion of the mandibular molars and supraocclusion of the maxillary incisors, along with some infraocclusion of the maxillary molars. Their findings indicated that the lower incisors were not in supraocclusion in cases of excessive overbite.

Weinberg (1959) in his study of incisal guidance relative to cuspal inclination in lateral movements found that the angle of the condyle travel on the balancing side, when 30^{o}, must have cuspal inclines of 30^{o} to effect harmonious interdigitation when the mandible returns to centric occlusion. On the working side it is more difficult to ascertain these values, but Weinberg concluded that a steeper incisal guidance is usually related to a deep temporal mandibular fossa, a steep antero-posterior condylar path, and a more severe Curve of Spee.

III. Occlusal Plane Inclination or the Severity of the Curve of Spee.

Von Spee (1890) observed the cusps and incisal ridges of the teeth tended to follow a curved line when the arches were observed from a point opposite the first molars. His early description of this phenomenon was apparently the first noted in the literature and the occlusal plane curve was thereby named the "Curve of Spee." This curvature refers to the saggital plane only.

Monson (1932) illustrated the relationship of the Curve of Spee to a related compensating curvature in a transverse plane showing a curvature bilaterally of the lower posterior teeth perhaps to facilitate lateral working and balancing of the occlusion. The author concluded, "Nothing anatomic can be reduced to the mathematical exactitude of geometrical terms."

Steadman (1939) maintained that to treat deep overbite cases the Curve of Spee had to be leveled out, but that relapse did occur. As historically described, the Curve of Spee is a curved plane passing through the posterior buccal cusp tips, the tip of the incisal edge of the cuspid, and the incisal edges of the incisors. He found that any individual may have as many as four distinct Curves of Spee, one for each quadrant of dentition.

In Figure 1, the chart depicts the various combinations of occlusal planes and Steadman designated them as contributory to: a) excessive overbite, b) adviseable overbite, and c) open bite.

Arita, Iwasawa, and Namura (1961) measured the Curve of Spee in 30 Japanese subjects (11 male and 19 female) with the following results:

1. There is no significant difference between males and females.

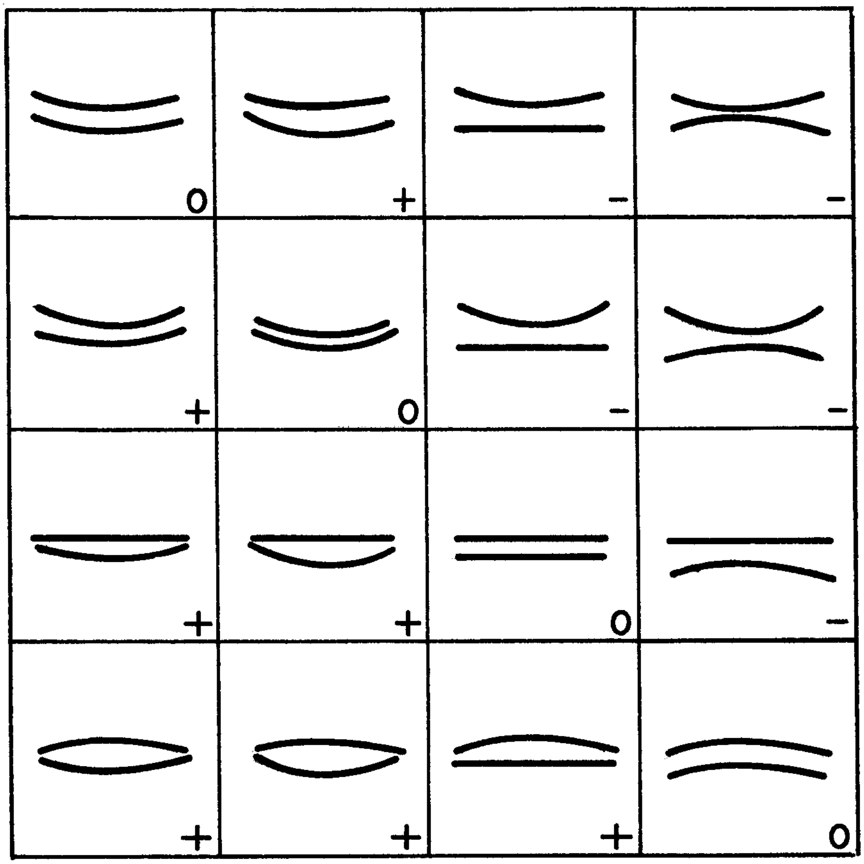
2. The severity of the curve depends on whether the first molars or second molars are used for the plane determination.

3. The greatest curvature exists in the area of the first and second bicuspids.

4. There appears to be no significant difference from the right or left side.

Horowitz and Hixon (1966) suggested a deep Curve of Spee usually reflects a compensation mechanism that permits adequate alignment of the teeth at the expense of increased overbite. Leveling of the occlusion of such a case requires additional arch length and may subsequently lead to a plan of treatment including extractions.

In Class II Division 1 malocclusions a hyper-



+=Excessive overbite
O=Advisable overbite
–=Open bite

COMBINATION OF CURVES OF SPEE WHICH MAY OCCUR: EACH CONTRIBUTORY TO A SPECIFIC OVERBITE-OVERJET SITUATION

FIGURE 1

active mentalis muscle may exert excessive pressure against the lower incisors forcing them lingually and then they over-erupt to produce an exaggerated Curve of Spee. Simultaneously the lower lip produces a pressure against the lingual surfaces of the maxillary teeth, producing a maxillary protrusion.

Craddock (1945) relates that although teeth are arranged in a horizontal plane, the second and third molars lie on a curve tangent and upward from the plane of occlusion. While present in both arches it is more noticeable in the mandibular arch. Not only are the lower second and third molars raised to meet their antagonists, the lower incisors are also raised, since they close further inside the upper teeth than do the canines, premolars, and first molars. Thus the lower teeth conform to a curve which is described as a segment of a circle extending from the incisal edges of the anterior teeth backwards in contact with the buccal cusps of the premolars and molars and terminating if extended on the anterior border of the condyle, and is known as the Curve of Spee. The radius of this curve generally varies inversely with the degree of inclination of the articular surface of the glenoid fossa, the amount of overbite, and the steepness of the cusp angles. In young persons whose glenoid fossae are deep and whose anterior overbite and cusps are not reduced by wear, the curve is usually distinct. In older individuals it tends to be flattened. Ordinarily the curve is defined in terms relative to the mandible and lower teeth.

The Curve of Spee should not be confused with the compensating curves; the former is an anatomical feature and the latter is a mechanical feature. A comprehensive curve is used in denture construction which arranges the teeth of a denture in a pattern which provides mechanical advantages during mastication.

Shanahan (1958) concluded that while a true Curve of Spee exists in young patients, it tends to flatten and perhaps even reverse itself in older patients due to masticatory abrasions. A younger patient is more able to withstand unfavorable occlusal stresses, but through chewing and occlusal grinding the dentition evolves into a harmonious curvature, compatible with the movements of the mandible.

Through a reversal of curvature, the buccal cusps on the lower posterior teeth and the lingual cusps on the upper tend to wear away, and the supporting tissues are generally in healthy condition.

According to Bolthouse (1970) significant differences between the right and left sides of the same individual do exist, but generally the curves are nearly of the same degree. He also concluded that the flatter the occlusal curvature, the greater right to left side variation seemed to occur.

He attributed his conclusion to a varying rate of eruption, dissimilar condylar path inclines, skeletal or muscular asymmetry, unilateral chewing patterns, or perhaps a complex interrelationship involving several of these factors.

He also said the following:

1. A flattening of the Curve of Spee is correlated to an increase in age.

2. The Curve of Spee increases as does the overbite and overjet increase.

3. The shape and position of the mandible vary as does the Curve of Spee. In the more square gonial angle the dentitions appear to have flatter Curves of Spee, i.e., as the gonial angle and the ramus height increase, the mandibular body length diminishes and the Curve of Spee tends to be flatter.

IV. The Cuspal Angulation of the Posterior Teeth as Determinants of the Amount of Interdigitation of the Posterior Occlusion.

Hellman (1942) observed in his studies of influencing factors that:

1. There exists differences in the time of eruption of teeth among individuals with normal occlusion and malocclusions.

2. The total length of time required for the completion of the entire dentition differs.

3. Differences exist in the sequence followed by erupting teeth.

4. Differences in the growth of the alveolar processes and jaw bones accompany the eruption of teeth.

He also concluded that:

1. Occlusion of teeth is effected by the contacts of certain anatomical units which have gradually come about through evolution.

2. The trend in man is toward simplification in forms of teeth and reduction in number of occlusal contact units.

3. Evolution is not at an end, but continues to occur in the dentition.

Hellman also showed that through evolutionary processes man's dentition is showing a pattern of decreased jaw length, while the crown dimension of the teeth remains almost unchanged. The eruption pattern of a normal dentition is quite different than the pattern for cases resulting in malocclusions. More congenitally missing teeth are occurring with each succeeding generation and molars are tending to form with the fifth cusp missing more frequently.

Gregory (1941) stated that in the evolution of the jaws of the mammalian tree, the ramus grew posteriorly and upward resulting eventually in the approximation of the mandibular bone with the squamous portion of the temporal bone. A cushion or articular meniscus eventually resulted to form a physiologically complex joint capable of a variety of movements as seen in the highly diverse pathways of mandibular excursions. These excursions were accompanied concurrently with an occlusal relationship of the teeth of both jaws capable of performing the required tasks peculiar to the various forms of mammalian creatures.

The movements of which the mandible is capable dictate the function and capability of the resultant dentition. In man, since the groups of teeth vary as to the distance from the fulcrum (temporomandibular joint), their several leverages and moments of inertia differ accordingly as that they exhibit an early stage in the functional differentiation into incisors, canines, premolars, and molars.

As compared to apes, man's occlusion has, through evolutionary change, reduced the size of the canines, increased vertically, and the anterior segment of the dental arch has been retracted, resulting in a foreshortening of the dental arches, and a relative widening of the intermolar and intercuspid widths. However, the incisors and cuspids (both upper and lower) appeared to be the least altered.

The third molars tend to reduce in size and occasionally failed to form. The first molars tended to lose the fifth cusp and fell into a four cusped pattern.

Broadbent (1941), in his study of the ontogenic development of the occlusion, stated that in the child the 6's are edge to edge until the last deciduous molars are shed, and at such time with the eruption of the cuspids, the bicuspids are positioned distally to take up the "leeway" space afforded by the first and second deciduous molars. Growth and proper eruption lead to normal occlusion. However, if this fails to occur in orderly and proper fashion, crowding will result and malocclusion will follow.

Supportive alveolar bone must develop accordingly to provide as adequate basal arch for the teeth as they erupt. A deficiency in skeletal development will also contribute toward crowding of the dentition resulting in malocclusions.

Begg (1971) appears convinced that modern man's dentition is devoid of the coarse diet found in the ancient Stone Age man (approximated by today's Aboriginal) and that this dietary deficiency contributes to the prevalence of malocclusions observed today. Mesial and distal wear of teeth, coupled with a constant mesial migration, and continued occlusal eruption, prevented early man from developing malocclusions.

Begg substantiates the trend toward missing fifth cusps on molars, missing maxillary incisors and third molars, and an increase in arch length discrepancies resulting in malocclusions with his comparative studies on Aborgines and modern man.

He also concludes from the same studies that a tendency toward more bimaxillary protrusion with the incisors angled more severely in an anterior direction exists, and that a greater number of Class II and Class III malocclusions are observable than in early man.

Kloehn (1938) studied animal dentitions to attempt to relate the findings to human dentitions and summarized his findings (regardless of rodent, carnivore, or herbivore) thusly:

1. The periodontal membrane acts as a suspensory ligament and directs the occlusal stress to the alveolar bone. (The rodent incisor being one of the best illustrations.)

2. No tooth functions individually.

3. Never is the entire occlusal surface of a given tooth under functional stress involved at any single instant.

4. Root form reflects the function of the individual tooth and its occlusal stress.

5. There appears to be a uniform ratio between functioning surface and root area.

6. The human denture functions unilaterally similarly to that of the herbivorous animal.

7. Human dentition has continuous arch force with full mutual contact and facial musculature which resists occlusion stresses.

Wheeler (1950) in his summary of the human dentition concluded that all teeth do not meet the occlusal plane at a right angle, but rather in a manner showing mesial inclination of the crowns. This angle increases, from the molars which are almost upright and perpendicular to the occlusal plane, to the incisors which have a greater mesial angulation. An attempt to ascribe geometric measurements merely confused the researcher since:

1. Every segment of a tooth presents curved surfaces except where fractured or worn.

2. Lines bisecting the teeth from any aspect exhibit curvature.

3. The teeth are aligned to form arches.

4. The maxilla and mandible present curved lines only.

5. The mandible functions only in paths which are curved.

6. The occlusal and incisal surfaces of the teeth as arch units adapt themselves to curved planes (compensating occlusal curvatures).

CHAPTER III

MATERIALS AND METHODS

A. Materials

A total of sixty dry skulls were obtained from Mogul Educational Materials, Oshkosh, Wisconsin, for this study. Fifty adult skulls with permanent dentitions and full occlusal complements; five children's skulls with mixed or deciduous dentitions in full occlusion; and five skulls in the aged, completely edentulous, category were used.

These skulls were collected in India and are representative of a common socio-economic strata of the population. The various classes of occlusion were represented and restorations were not present in any of the teeth, indicating that dental treatment was not performed. Caries and periodontal problems were present to a limited degree, suggesting a diet low in carbohydrate content. Facet wear varied with the age of the dentition.

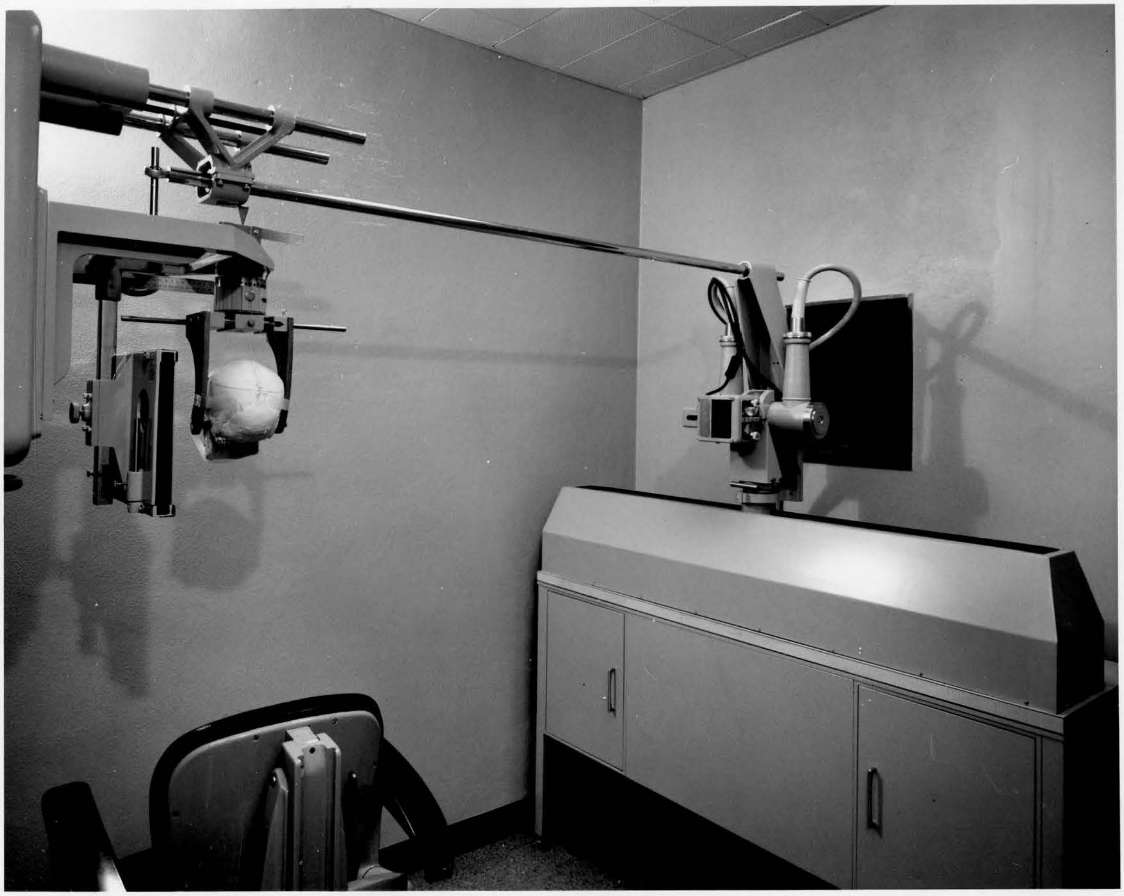
B. Methods

To study the aforementioned factors of occlusion, laminagraphic films were taken of both condyles and fossae on each individual skull with a plane of cut to include the long axis of the body of the mandible and teeth. The X-ray machine used was furnished by the Orthodontic Department, Loyola University Dental School. It was a Quint X-Ray Sectograph Cephalometer manufactured by the Quint X-Ray Company, Inc. Dr. R. W. Ricketts is a technical advisor and consultant to this firm (Figure 2, 3).

Each skull was positioned in the head holder by the use of the ear rods inserted reciprocally into the external auditory meatus. The head holder was adjustable so as to maintain a five foot target-anode distance. The cassette was adjusted vertically, horizontally, and to the proper distance from the target object. The plane of cut of the sectograph was determined by measuring the skull position or by sighting a vertical from the plane selector (Figure 4).

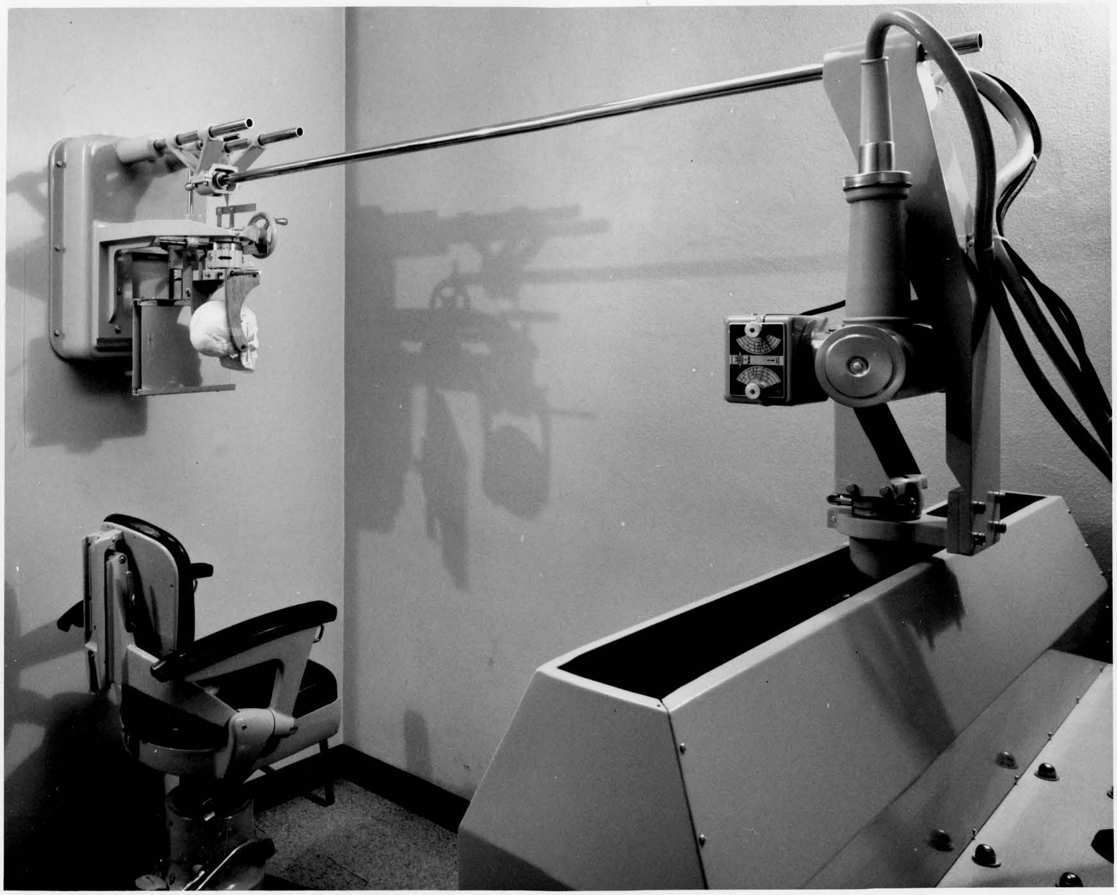
The width of cut was determined by the magnitude of tube travel or patient film distance. It was found through trial and error that the most consistent results of the laminagraphic study were obtained by utilization of the following settings for the sectograph:

1. Target-object-anode distance...5 feet.
2. 50 milliamps
3. 52 kilovolts



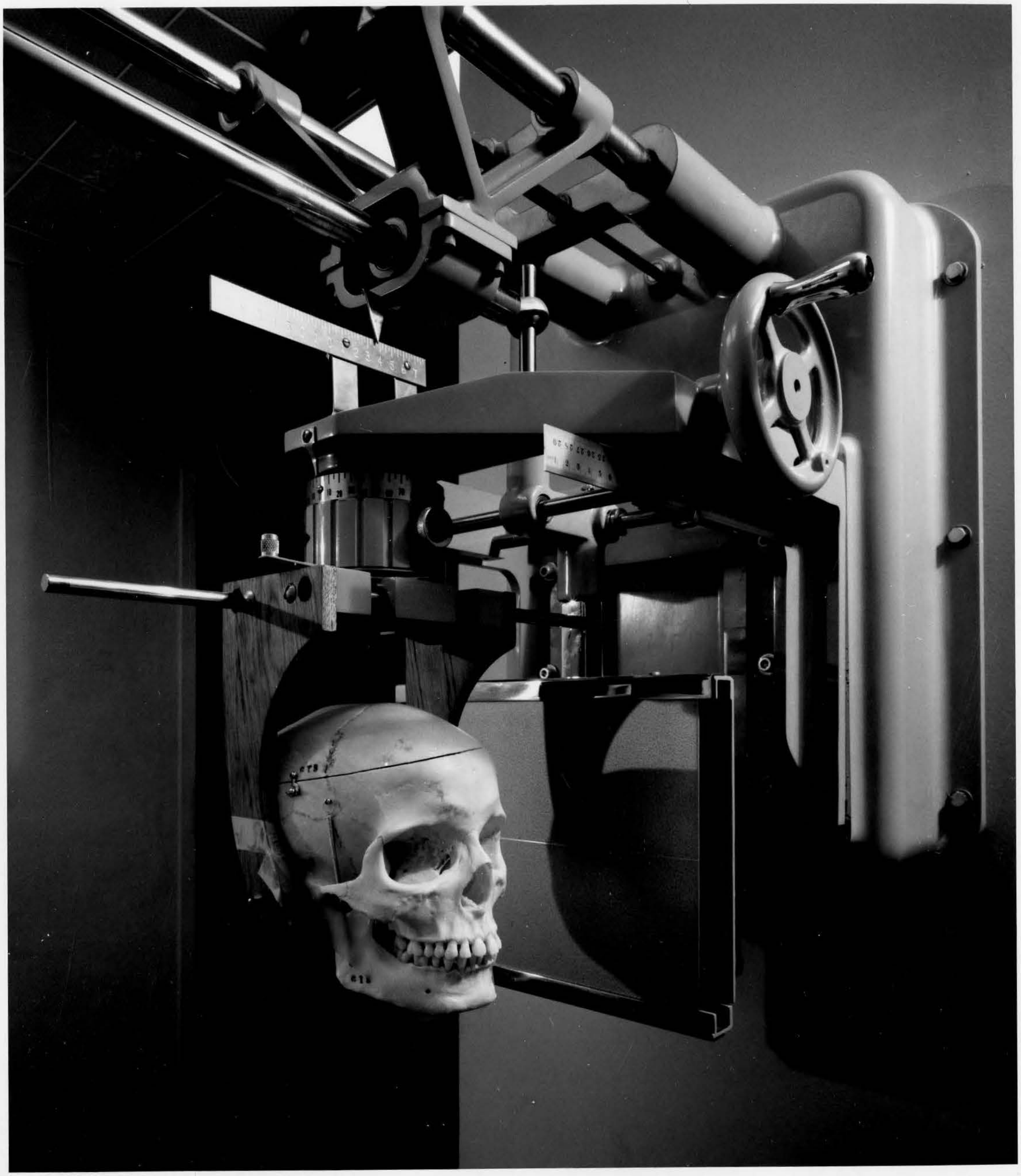
QUINT SECTOGRAPH (LAMINAGRAPH) CEPHALOMETER
SHOWING TUBE HEAD

FIGURE 2



QUINT SECTOGRAPH CEPHALOMETER SHOWING
HEAD HOLDER

FIGURE 3



HUMAN SKULL MOUNTED IN HEAD HOLDER OF QUINT SECTOGRAPH CEPHALOMETER

FIGURE 4

4. Target to film distance...15 centimeters.
5. Focal point from mid-point of skull to target area...3.5 centimeters.
6. 20^{o} oblique setting so as to cross section the condylar head at its greatest curvature or center, and to include the entire body of the mandible and the existent dentition needed for supplemental measurements.
7. The exposure time was 1.25 seconds.

The above settings were used for all films with exceptions being made for skulls of greater or lesser bilateral dimension than average. In such instances the figure of 3.5 centimeters (focal point to mid-point in skull) was adjusted to 3.25 centimeters for smaller than average skulls (children) and to 3.75 centimeters in the larger than average skulls, bilaterally. These sizes were obtained by pre-measuring the bizygomatic dimension of each skull. In the data section of this thesis the skulls exhibiting deviations from the average dimension are noted as to their adjusted settings as the distance from mid-point of the skull to target area varied.

The cassette used in this project was designed and manufactured by DuPont, Inc., and was the "Halsey Rigid Form" cassette. It held an 8x10 ParSpeed film and had a .0025 lead backing for phototiming purposes and a Magnesium Phenolic front. The film of choice was DuPont Cronex-4 medical X-Ray film and exposure time was 1.25 seconds.

After exposure, the films were developed by a Profexray Automatic X-Ray developing unit. This machine was manufactured by a division of Litton Industries. The exposed films were fed into the unit which developed, rinsed, fixed, rinsed, and then air dried the film; the entire cycle taking three minutes.

The rinse water entering the unit was maintained at 80° Fahrenheit by mixing valves. The developing solution was maintained at 32.5° C. or 91° F., and the air dryer operated at 50° C. or 120° F. This unit was a boon to the researcher who needed immediate results before proceeding to the next film. It provided a convenience heretofore experienced by few radiographic students who researched a large number of films. The developing technique was as uniform as could be obtained for consistent results (Figure 5).

Upon completion, each film was individually inspected to ascertain if the essential anatomical landmarks were present. If deemed acceptable, the films were attached to a sheet of acetate tracing paper of .005

PROFEXRAY AUTOMATIC X-RAY DEVELOPING UNIT
USED IN THIS RESEARCH

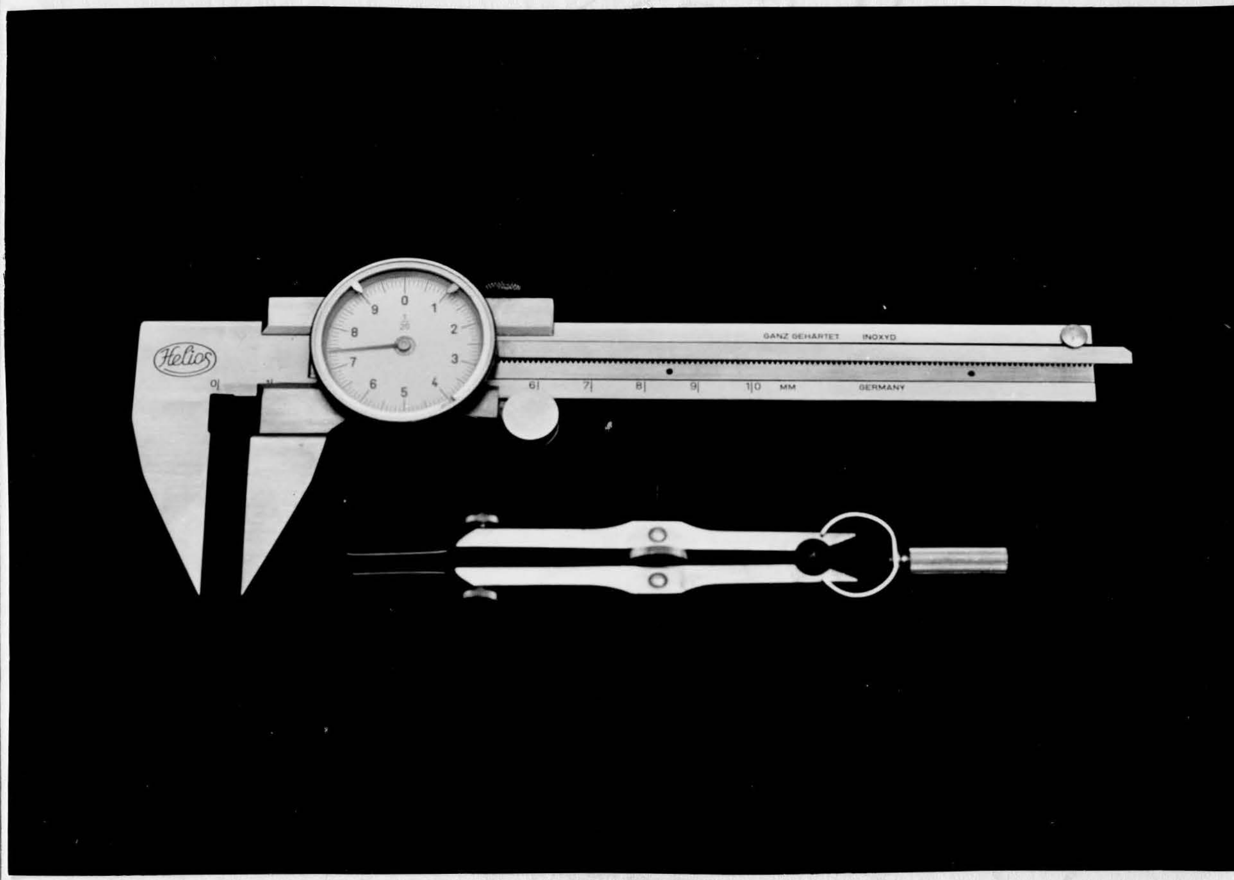
FIGURE 5

thickness. To perform the tracing of each laminagraph, a Betta tracing box was used with fluorescent illumination. The measuring devices used were protractors, a Helios caliper, and a millimeter ruler (Figure 6). The lines were drawn with a 5H electronic lead pencil to keep the lines as fine and sharp as possible to minimize error.

The subsequent tracings were accomplished on the acetate sheets showing the following anatomical structures:

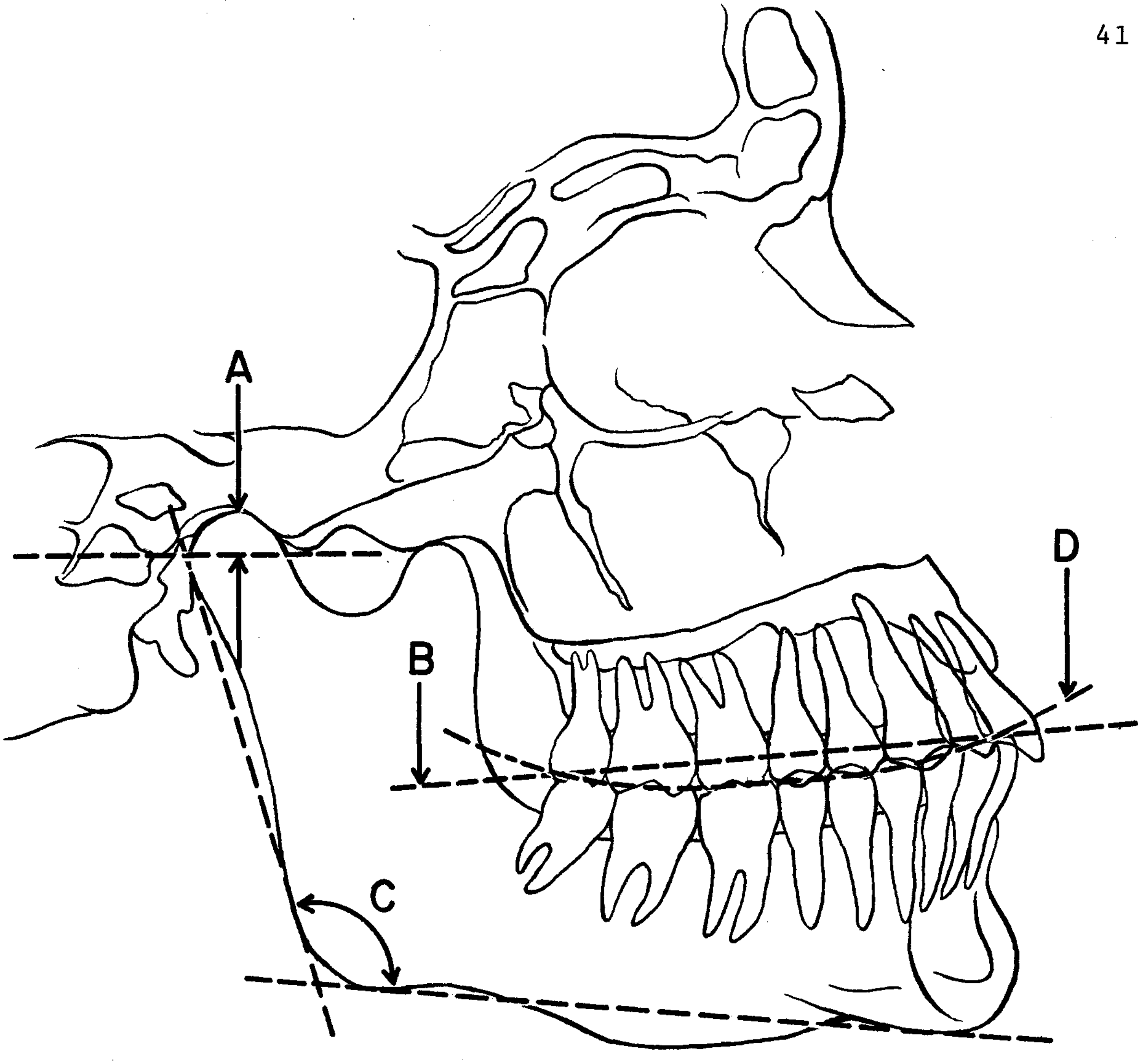
1. Anterior articular eminence.
2. Posterior articular eminence.
3. Superior curvature of glenoid fossa.
4. Head of condyle.
5. Posterior border of mandibular ramus.
6. Inferior border of mandibular body.
7. Cuspal tips of all teeth in mandible from the terminal molar to the most mesial incisor forming the Curve of Spee.
8. Occlusal plane, determined by the highest cuspal tip on the most terminal mandibular molar, and the highest point on the incisal edge of the most anterior mandibular incisor (Figures 7, 8, 9, 10).

To calculate the depth of the glenoid fossa a line



HELIOS CALIPER AND BOW DIVIDER USED IN THIS RESEARCH

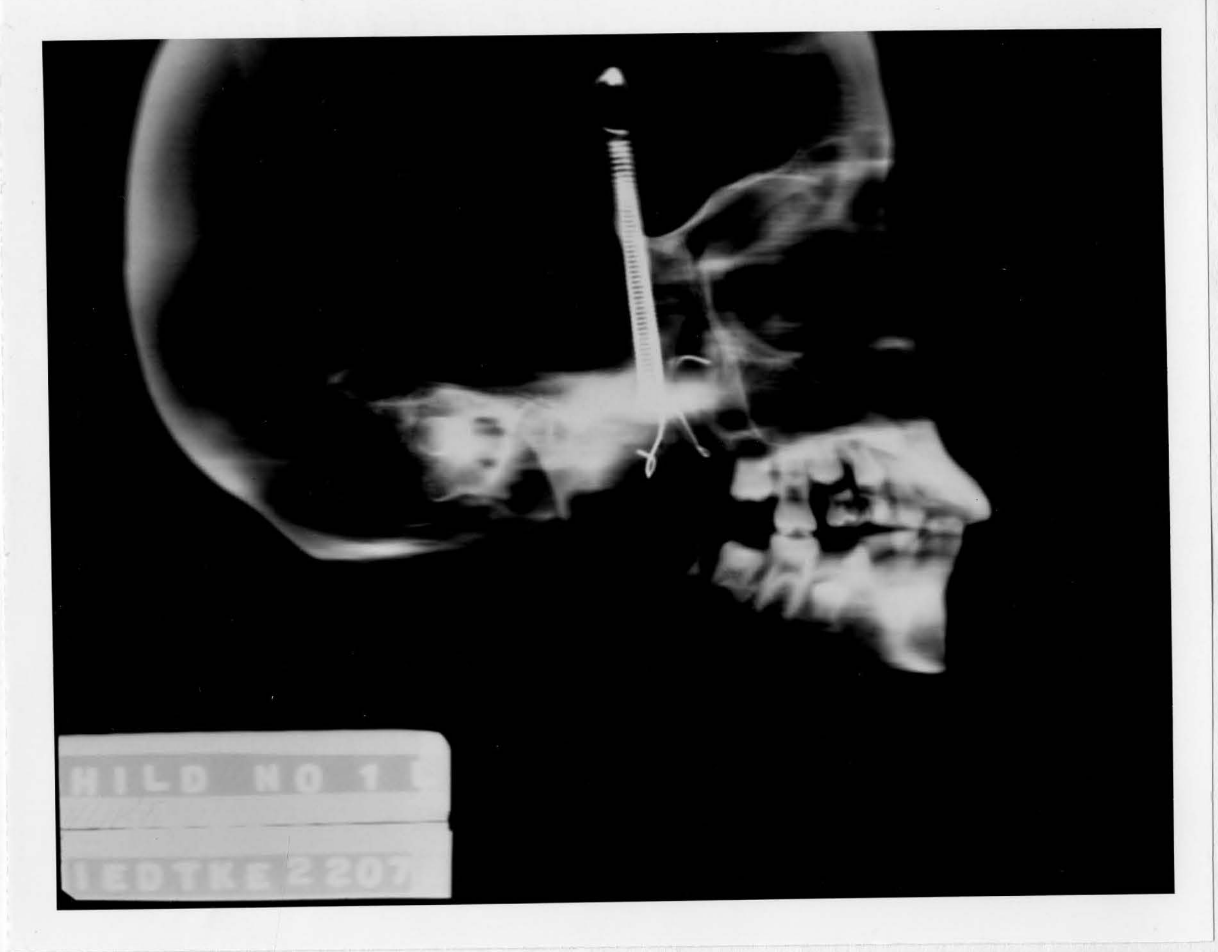
FIGURE 6



A= Depth of Glenoid Fossa
B= Occlusal plane
C= Gonial angle
D= Curve of Spee

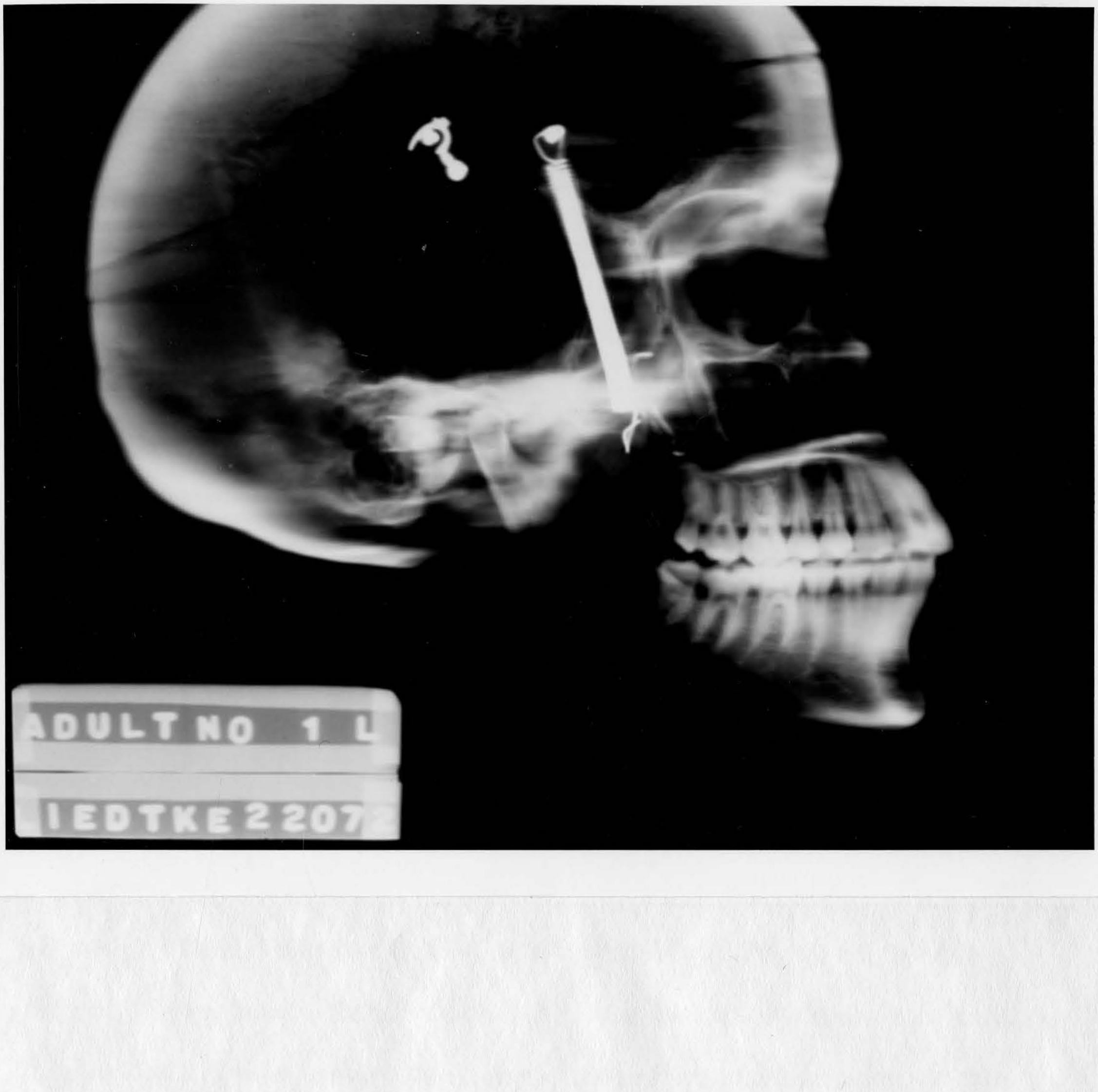
VIEW OF SECTION PRODUCED BY LAMINAGRAPHIC TECHNIQUE AND ANATOMICAL LANDMARKS USED IN COLLECTION OF MENSURAL DATA

FIGURE 7



LAMINAGRAPHIC VIEW OF CHILD SKULL (LEFT SIDE)

FIGURE 8



LAMINAGRAPHIC VIEW OF ADULT SKULL (LEFT SIDE)

FIGURE 9

LAMINAGRAPHIC VIEW OF AGED SKULL (LEFT SIDE)

FIGURE 10

was drawn tangent to the inferior surface of both the anterior and posterior articular eminence. The superior curvature of the glenoid fossa was then traced and a line was constructed perpendicular to the base line (connecting the anterior and posterior eminence), and extending through the highest contour of the fossa. A Helios caliper, sensitive to .05 mm., was used to measure the distance from the intersection of the perpendicular line and the glenoid fossa curvature to the intersection of the perpendicular line and the tangent line connecting the anterior and posterior eminences. This measurement was recorded in millimeters (Figure 7) as the glenoid fossa depth.

During this determination, the actual skull was examined visually by the author to better familiarize him with the variations in the anatomical structures so as to be more accurate in the selection of the landmarks used. This lessened the probability of error which might have been introduced by superimposition of various layers of bone over the area under observation or the degree of anatomical variation of each fossa and condyle.

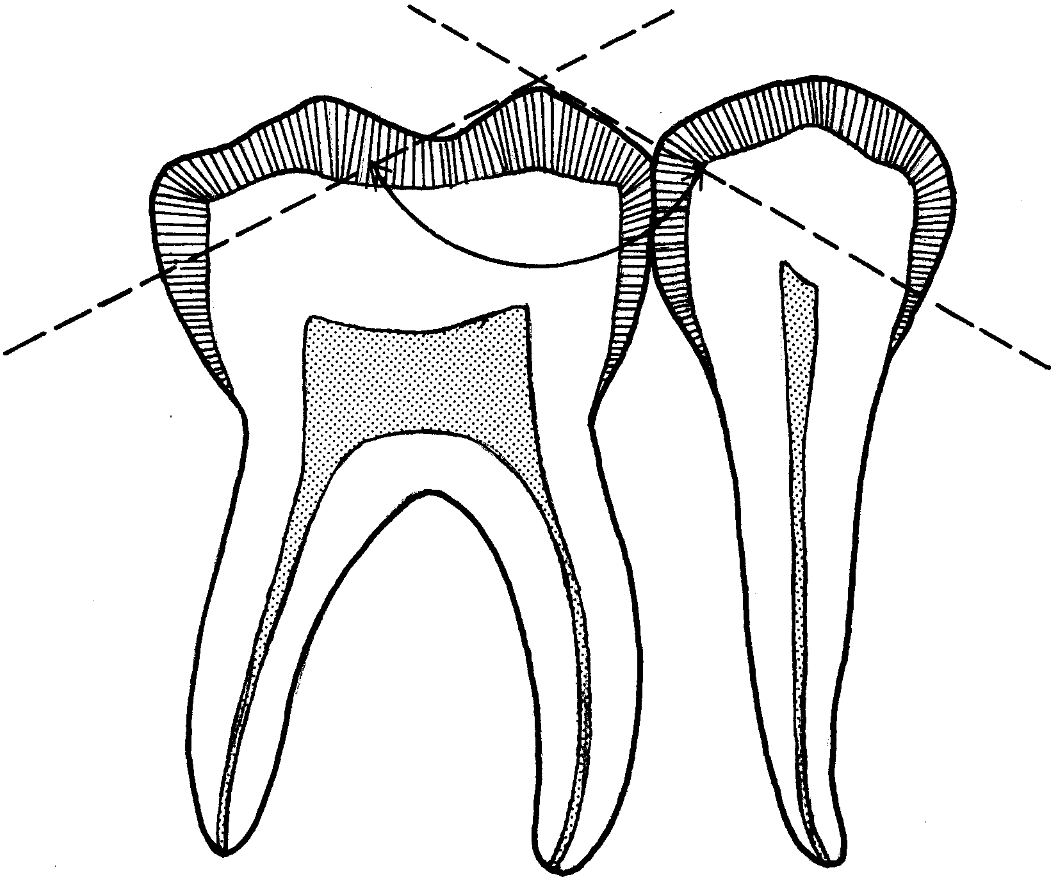
The Gonial angle was determined by constructing two lines: one line tangent to the most distal aspect of the mandibular condyle and the most distal inferior aspect of the ramus of the mandible, and one line tangent to the most distal inferior aspect of the body of the mandible and the most inferior aspect of the symphysis of the mandible. The intersection of these lines formed the Gonial angle, measurable with a protractor and recorded in degrees (Figure 7).

The degree of curvature of the Curve of Spee was calculated by first the determination of an occlusal plane derived from two points: the most superior cuspal tip on the terminal mandibular molar and the most superior incisal edge of the most anterior incisor tooth of the mandible. A straight line connected these two points, while the Curve of Spee was formed by connecting with a line the most superior cuspal tips of all the teeth found in the mandibular arch as presented in the laminagraph. At the point where the Curve of Spee contained its greatest deviation from the base line or occlusal plane line, the deviation was measured with the Helios caliper. This indicated the severity of the Curve of Spee as related to the occlusal plane. This measurement was recorded in millimeters (Figure 7).

The angulation of the posterior cusps was determined by using the mesial cuspal tip of the lower first molar as the apex of the angle. The intersecting lines drawn will pass through this point and 1) through the most superior point of the contact area between the lower second bicuspid and the lower first molar, and 2) through the point determined as the central fossa of the occlusal table of the lower first molar: this point being found in the approximate center of the occlusal table of the lower first molar and at a depth determined by the enamel contour at this location indicating the central fossa. This angle formed was measured with a protractor and recorded in degrees (Figure 11).

To determine the exact amount of overbite, a pencil line was drawn with a 5H pencil on the labial surface of the lower incisor, using the incisal edge of the maxillary incisor as an absolute guide for this line with the jaws in maximum occlusion. The dimension from the incisal edge of the mandibular incisor to this line was then measured with the Helios caliper and recorded in millimeters (Figure 12) as the overbite dimension.

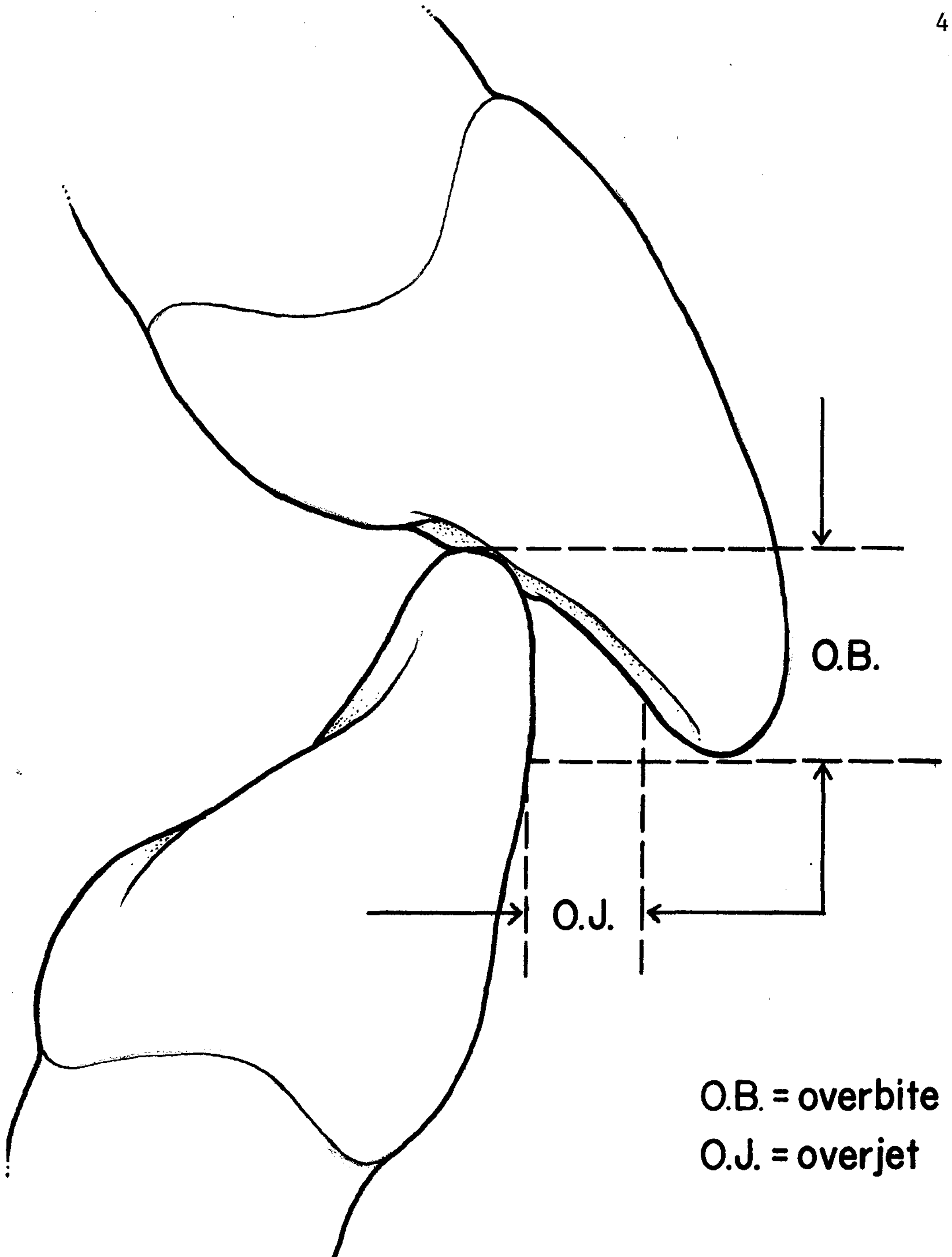
Overjet was determined in a similar manner using the caliper directly between the labial enamel of the lower incisor and the lingual enamel of the maxillary incisor where span would permit. Where insufficient space was available a bow divider with a fine adjustment was used. The distance between the two points was then



CUSPAL ANGULATION

VIEW OF SECTION OF POSTERIOR TEETH AND PLANES UTILIZED TO OBTAIN CUSPAL ANGULATION

FIGURE 11



VIEW OF OVERBITE AND OVERJET OF ANTERIOR TEETH AND LIMITS UTILIZED TO OBTAIN MEASUREMENTS

FIGURE 12

measured with a caliper and recorded in millimeters (Figures 6, 12) as the overjet dimension.

Appropriate statistical tests were utilized to correlate the findings. Descriptive statistics were obtained for all the variables being studied in the entire sample. These included the mean, standard deviation, standard error of the mean, the maximum value, the minimum value, and the range for these two measurements. These figures were also calculated for each individual group (classified as to occlusal type). Then matched sample T-tests were performed which compared the findings within the groups as to right side vs. left side.

Independent T-tests were then employed to compare the findings for all combinations of comparisons between the various groups, as classified by occlusion types.

Finally, coefficient of correlation tests were performed between the variables of each group in an attempt to show an interrelationship of the variables studied.

All data was processed and the tests performed by the Computer Center of the Loyola University Medical Center Information Service Department.

CHAPTER IV

FINDINGS

The following findings were obtained in this research project and are composed of the original mensural data and the statistical analysis of this data. The following data is presented in the tables.

1.) Original data obtained from the dry skull measurements and acetate tracings of laminagraphs (Tables 1-9).

2.) Descriptive statistics for the combined sample (Table 10) showing mean, standard deviation, standard error, sample size, maximum and minimum values, and the range of values. Angle's classification was used to divide Groups 1, 2, and 3 by occlusion type. The five groups studied are listed as follows:

Group 1 - Adults with Class I occlusion (33 skulls).

Group 2 - Adults with Class II malocclusions (14 skulls).

Group 3 - Adults with Class III malocclusions (3 skulls).

Group 4 - Children with mixed or deciduous dentitions (5 skulls).

Group 5 - Aged skulls of the edentulous category (5 skulls).

DESCRIPTIVE STATISTICS FOR ENTIRE SAMPLE

Variable No.	Mean	Stand. Dev.	Stand. ErrorM.	S	Max.	Min.	Range
R. Fossa	6.4775	1.2180	0.1572	60	9.1000	3.3500	5.7500
R. Spee	2.1280	1.0611	0.1431	55	4.6000	-0.6500	5.2500
R. Gonial	120.1132	7.1348	0.9211	60	139.0000	103.5000	35.5000
R. Cuspal	121.4284	22.5623	3.0150	55	152.0000	86.0000	66.0000
Overbite	1.2609	1.5733	0.2122	55	4.3500	-4.1500	8.5000
Overjet	1.0673	1.7334	0.2337	55	5.5000	-3.0000	8.5000
L. Fossa	6.3938	1.3228	0.1708	60	10.2000	2.2000	8.0000
L. Spee	2.1800	1.0749	0.1449	55	4.4500	-0.3500	4.8000
L. Gonial	119.0998	7.2274	0.9331	60	136.0000	100.0000	36.0000
L. Cuspal	124.3480	23.7151	3.1691	55	162.0000	85.0000	77.0000

TABLE 10

3.) Mean values for measurements by Groups (Table 11).

4.) Matched sample t-tests comparing measurements within groups, as to right vs. left side, are seen in Tables 12 and 13. A standard two-tailed t-table was employed to ascertain the significance of the values found.

These tests showed no significant difference between variables within any groups, except the gonial angles of Group 4 and Group 5. The differences are as follows:

Group 4) t-table value 2.78 Actual $t=6.918$ $.01>P>.001$

Group 5: t-table value 2.78 Actual $t=3.162$ $.5>P>.01$

5.) Independent t-tests

A. The tests comparing Group 1 with Group 2 (Table 14) showed a statistically significant difference only in the overjet comparison. (Actual $t=2.174$ $.05>P>.01$)

B. The tests comparing Group 1 with Group 3 (Table 15) again showed a significant difference to exist only in the overjet comparison. (Actual $t=3.196$ $.01>P>.001$)

C. In the tests comparing Group 1 with Group 4 (Table 16) the following significant differences occurred:

Left fossa vs. Left fossa
Actual $t=2.428$ $.05>P>.01$

Right Spee vs. Right Spee
Actual $t=3.327$ $.01>P>.001$

Left Spee vs. Left Spee
Actual $t=3.263$ $.01>P>.001$

MEAN VALUES OF VARIABLES, GROUPS 1-5

Variables	Group 1	Group 2	Group 3	Group 4	Group 5
R. Fossa	6.680	6.500	6.833	5.800	5.540
R. Spee	2.318	2.101	2.150	0.934	
R. Gonial	119.242	117.214	122.167	129.800	123.300
R. Cuspal	124.667	127.821	119.833	107.400	
Overbite	1.045	1.836	-0.117	1.900	
Overjet	.879	1.943	-2.133	1.780	
L. Fossa	6.656	6.311	6.467	5.156	6.090
L. Spee	2.309	2.521	1.467	0.800	
L. Gonial	118.318	117.821	122.500	124.600	120.300
L. Cuspal	129.818	131.429	111.833	100.800	

Group 1- Adults with Class I occlusion (33 skulls).

Group 2- Adults with Class II malocclusions (14 skulls).

Group 3- Adults with Class III malocclusions (3 skulls).

Group 4- Children with mixed or deciduous dentitions (5 skulls).

Group 5- Aged skulls of the edentulous category (5 skulls).

TABLE 11

MATCHED SAMPLE T-TESTS, GROUPS 1-5, RIGHT VS. LEFT

No. Observ.	Gp.	Variable	Mean of Diff.	Stand. Dev.Diff.	Stand. E.Diff.	t-Value	P-Value
33	1	R. Fossa L. Fossa	0.024	0.950	0.165	0.147	*
33	1	R. Spee L. Spee	0.009	1.151	0.200	0.045	*
33	1	R. Gonial L. Gonial	0.924	3.849	0.670	1.379	*
33	1	R. Cuspal L. Cuspal	-5.152	15.921	2.771	1.859	**
14	2	R. Fossa L. Fossa	0.189	0.788	0.211	0.899	*
14	2	R. Spee L. Spee	-0.420	1.343	0.359	1.170	*
14	2	R. Gonial L. Gonial	-0.607	2.625	0.702	0.865	*
14	2	R. Cuspal L. Cuspal	-3.607	20.459	5.468	0.660	*
3	3	R. Fossa L. Fossa	0.367	2.183	1.260	0.291	*
3	3	R. Spee L. Spee	0.683	0.957	0.553	1.237	*
3	3	R. Gonial L. Gonial	-0.333	4.368	2.522	0.132	*
3	3	R. Cuspal L. Cuspal	8.000	16.210	9.359	0.855	*

TABLE 12

MATCHED SAMPLE T-TESTS, GROUPS 1-5, RIGHT VS. LEFT

No. Observ.	Gp.	Variable	Mean of Diff.	Stand. Dev.Diff.	Stand. E. Diff.	t-Value	P-Value
5	4	R. Fossa L. Fossa	0.644	0.863	0.386	1.668	*
5	4	R. Spee L. Spee	0.134	0.449	0.201	0.667	*
5	4	R. Gonial L. Gonial	5.200	1.681	0.752	6.918	****
5	4	R. Cuspal L. Cuspal	6.600	23.755	10.624	0.621	*
5	5	R. Fossa L. Fossa	-0.550	1.025	0.459	1.199	*
5	5	R. Gonial L. Gonial	3.000	2.121	0.949	3.162	***

* P-Value greater than .10 probability level (10%)

** P-Value greater than .05 probability level (5%)

*** P-Value greater than .01 probability level (1%)

**** P-Value greater than .001 probability level (.1%)

TABLE 13

INDEPENDENT T-TESTS, GROUP 1 VS. GROUP 2

No. Observ.	Gp.	Variable	Mean	Stand. Dev.	Diff.Mean Stand. E.	t-Value	P-Value
33+14	1 2	R. Fossa R. Fossa	6.680 6.500	.977 1.444	0.361	0.499	*
33+14	1 2	L. Fossa L. Fossa	6.656 6.311	1.177 1.518	0.409	0.843	*
33+14	1 2	R. Spmeal R. Spee	2.318 2.101	0.911 1.350	0.377	0.643	*
33+14	1 2	L. Spee L. Spee	2.309 2.521	1.016 1.058	0.328	0.648	*
33+14	1 2	R. Gonial R. Gonial	119.242 117.214	6.020 8.099	2.133	0.951	*
33+14	1 2	L. Gonial L. Gonial	118.318 117.821	7.431 7.426	2.369	0.209	*
33+14	1 2	R. Cuspal R. Cuspal	124.667 127.821	14.277 13.766	4.507	0.699	*
33+14	1 2	L. Cuspal L. Cuspal	129.818 131.429	15.690 12.389	4.725	0.341	*
33+14	1 2	Overbite Overbite	1.045 1.836	1.646 1.457	0.508	1.555	*
33+14	1 2	Overjet Overjet	0.879 1.943	1.567 1.453	0.489	2.174	***

TABLE 14

INDEPENDENT T-TESTS, GROUP 1 VS. GROUP 3

No. Observ.	Gp.	Variable	Mean	Stand. Dev.	Diff. Mean Stand. E.	t-Value	P-Value
33+3	1	R. Fossa	6.680	0.977	0.631	0.243	*
	3	R. Fossa	6.833	1.824			
33+3	1	L. Fossa	6.656	1.177	0.692	0.274	*
	3	L. Fossa	6.467	0.462			
33+3	1	R. Spee	2.318	0.911	0.549	0.306	*
	3	R. Spee	2.150	0.926			
33+3	1	L. Spee	2.309	1.016	0.605	1.394	*
	3	L. Spee	1.467	0.764			
33+3	1	R. Gonial	119.242	6.019	3.542	0.826	*
	3	R. Gonial	122.167	2.566			
33+3	1	L. Gonial	118.318	7.431	4.458	0.938	*
	3	L. Gonial	122.500	6.763			
33+3	1	R. Cuspal	124.667	14.277	8.531	0.567	*
	3	R.Cuspal	119.833	11.878			
33+3	1	L. Cuspal	129.818	15.690	9.279	1.938	**
	3	L. Cuspal	111.833	9.278			
33+3	1	Overbite	1.046	1.646	0.963	1.207	*
	3	Overbite	-0.117	0.202			
33+3	1	Overjet	0.879	1.567	0.943	2.196	****
	3	Overjet	-2.133	1.501			

TABLE 15

INDEPENDENT T-TESTS, GROUP 1 VS. GROUP 4

No. Observ.	Gp.	Variable	Mean	Stand. Dev.	Diff.Mean Stand. E.	t-Value	P-Value
33+5	1	R. Fossa	6.680	0.977	0.531	1.716	**
	4	R. Fossa	5.800	1.628			
33+5	1	L. Fossa	6.656	1.177	0.618	2.428	***
	4	L. Fossa	5.156	1.956			
33+5	1	R. Spee	2.318	0.911	0.416	3.327	****
	4	R. Spee	0.934	0.348			
33+5	1	L. Spee	2.309	1.016	0.463	3.263	****
	4	L. Spee	0.800	0.334			
33+5	1	R. Gonial	119.242	6.019	2.855	3.698	****
	4	R. Gonial	129.799	5.358			
33+5	1	L. Gonial	[illegible]	[illegible]	3.458	1.817	**
	4	L. Gonial	124.599	5.044			
33+5	1	R. Cuspal	124.667	14.277	7.417	2.328	***
	4	R. Cuspal	107.399	22.777			
33+5	1	L. Cuspal	129.818	15.690	7.318	3.967	****
	4	L. Cuspal	100.799	11.099			
33+5	1	Overbite	1.046	1.646	0.768	1.113	*
	4	Overbite	1.900	1.166			
33+5	1	Overjet	0.879	1.567	0.738	1.221	*
	4	Overjet	1.780	1.279			

TABLE 16

Right gonial angle vs. Right gonial angle
Actual t=3.698 .01>P>.001

Right cuspal angle vs. Right cuspal angle
Actual t=2.328 .05>P>.01

Left cuspal angle vs. Left cuspal angle
Actual t=3.967 .01>P>.001

D. The test comparing Group 1 with Group 5 (Table 17) showed the following significant difference:

Right fossa vs. Right fossa
Actual t=2.418 .05>P>.01

E. The test comparing Group 2 to Group 3 (Table 18) revealed the following significant differences:

Left cuspal angle vs. Left cuspal angle
Actual t=2.562 .05>P>.01

Overbite vs. Overbite
Actual t=2.259 .05>P>.01

Overjet vs. Overjet
Actual t=4.389 .01>P>.001

6.) Coefficient of correlation tests showed the following significant correlations to exist (Table 19) except for Group 1 which showed no significant correlations for any of the variables studied:

A. Group 2 showed the gonial angle to have a moderately significant negative correlation to overbite. (Actual r=-.6233 .01>P>.001) Also, Group 2 showed the gonial angle to have a moderately significant correlation to overjet (Actual r=-.5887 .01>P>.001).

B. Group 3 showed the depth of the glenoid

INDEPENDENT T-TESTS, GROUP 1 VS. GROUP 5

No. Observ.	Gp.	Variable	Mean	Stand. Dev.	Diff.Mean Stand. E	t-Value	P-Value
33+5	1	R. Fossa	6.680	0.977	0.471	2.418	***
	5	R. Fossa	5.540	1.023			
33+5	1	L. Fossa	6.656	1.777	0.549	1.032	*
	5	L. Fossa	6.090	0.819			
33+5	1	R. Gonial	119.242	6.019	2.936	1.383	*
	5	R. Gonial	123.299	6.852			
33+5	1	L. Gonial	118.318	7.431	3.519	0.563	*
	5	L. Gonial	120.299	6.496			

* P-Value greater than .10 probability level (10%)

** P-Value greater than .05 probability level (5%)

*** P-Value greater than .01 probability level (1%)

**** P-Value greater than .001 probability level (.1%)

TABLE 17

INDEPENDENT T-TESTS, GROUP 2 VS. GROUP 3

No. Observ.	Gp	Variable	Mean	Stand. Dev.	Diff.Mean Stand. E.	t-Value	P-Value
14+3	2	R. Fossa	6.499	1.443	0.954	0.349	*
	3	R. Fossa	6.833	1.824			
14+3	2	L. Fossa	6.310	1.518	0.906	0.172	*
	3	L. Fossa	6.467	0.462			
14+3	2	R. Spee	2.101	1.350	0.828	0.059	*
	3	R. Spee	2.150	0.926			
14+3	2	L. Spee	2.521	1.058	0.651	1.619	*
	3	L. Spee	1.467	0.764			
14+3	2	R. Gonial	117.214	8.099	4.834	1.024	*
	3	R. Gonial	122.166	2.566			
14+3	2	L. Gonial	117.821	7.426	4.670	1.002	*
	3	L. Gonial	122.500	6.764			
14+3	2	R. Cuspal	127.821	13.766	8.607	0.928	*
	3	R. Cuspal	119.833	11.878			
14+3	2	L. Cuspal	131.428	12.389	7.647	2.562	***
	3	L. Cuspal	111.833	9.278			
14+3	2	Overbite	1.836	1.457	0.864	2.259	***
	3	Overbite	-0.117	0.202			
14+3	2	Overjet	1.943	1.453	0.929	4.389	****
	3	Overjet	-2.133	1.501			

TABLE 18

COEFFICIENT OF CORRELATION TESTS, WITHIN GROUPS

Variable	Group 1	Group 2	Group 3	Group 4	Group 5
Fossa vs. Spee	-0.0516	-0.1984	0.3781	-0.1651	
Fossa vs. Genial A.	-0.2907	-0.1794	-0.8974 *	-0.9296 ****	0.0978
Fossa vs. Cuspal A.	0.1425	-0.1287	0.8492 *	-0.8731 ***	
Fossa vs. Overbite	0.0222	0.0645	0.4271	-0.1219	
Fossa vs. Overjet	-0.4322	0.2972	-0.4271	0.3098	
Spee vs. Genial A.	-0.1816	-0.3408	0.0691	-0.1084	
Spee vs. Cuspal A.	0.2366	-0.4548	-0.1677	0.0117	
Spee vs. Overbite	0.0540	0.3708	0.9986 ****	0.6439 *	
Spee vs. Overjet	0.1743	0.2104	-0.9986 ****	0.8021 **	
Gonial vs. Cuspal A.	-0.1645	-0.0641	-0.9951 ****	0.7216 *	
Genial vs. Overbite	-0.1088	-0.6233 ****	0.0156	0.3528	
Genial vs. Overjet	0.1418	-0.5887 ***	-0.0156	-0.2105	

* P>.1 (10%), ** P>.05 (5%), *** P>.01 (1%), **** P>.001 (.1%).

TABLE 19

fossa to have a highly significant negative correlation to the gonial angle. (Actual r=-.8974 P>.1) Group 3 showed the glenoid fossa to have a highly significant positive correlation to the cuspal angulation. (Actual r=.8492 P>.1) Group 3 showed the Curve of Spee to have a highly significant positive correlation to the overbite. (Actual r=.9986 .01>P>.001) Group 3 showed the Curve of Spee to have a highly significant negative correlation to the overjet. (Actual r=-.9986 .01>P>.001) Lastly, Group 3 showed the gonial angle to have a highly significant negative correlation to the cuspal angulation. (Actual r=-.9951 .01>P>.001)

C. Group 4 showed the following significant correlations: The glenoid fossa had a highly significant negative correlation to the gonial angle. (Actual r=-.9296 .01>P>.001), the glenoid fossa negatively correlated to the cuspal angulation (Actual r=-.8731 .05>P>.01), and the Curve of Spee positively correlated to the overbite (Actual r=.6439 P>.1). The Curve of Spee showed a highly significant positive correlation to overjet (Actual r=.8021 .1>P>.05) and the gonial angle showed a moderately significant positive correlation to the cuspal angulation (Actual r=.7216 .1>P>.05).

CHAPTER V

DISCUSSION

Due to the fact that a review of literature indicates very little work has been attempted in the direction of this research, it is difficult to compile a base of statistics or norms with which to compare these findings. However, an attempt will be made to correlate the findings, in a supportive or contradictory manner, to previous research where possible.

In comparing the measurements of this study, it was felt necessary to make comparisons between the right and left sides of each group. Since no significant differences were found, thus showing bilateral symmetry, the researcher then felt secure in proceeding with further comparisons between groups and correlations within groups.

As a further check into the possibility of bilateral assymetry, a human mandible (Figure 13) was examined, photographed, and then the condylar heads were sectioned to further demonstrate the degree to which asymmetry may occur (Figure 14). The result is seen to represent many shapes, depending upon the depth of the section. Because of this variation, extreme precision is to be sought, if

VIEW OF HUMAN MANDIBLE USED TO SHOW BILATERAL ASYMMETRY WHICH MAY EXIST

FIGURE 13

VIEW OF SECTIONED CONDYLES OF MANDIBLE SHOWN IN FIGURE 13. TOP ROW-RIGHT SIDE-LATERAL TO MEDIAL SECTIONS. BOTTOM ROW-LEFT SIDE-MEDIAL TO LATERAL SECTIONS

FIGURE 14

the researcher is to have a meaningful radiographic analysis as in the case of the laminagraph which provided an X-ray of any desired depth of section. Such a precise approach was worked for in this research to obtain the most symmetrical and consistently reproducible sectioning of the subjects through laminagraphy. The mensural criteria obtained from the acetate tracings of the laminagraphs, when used in matched sample T-tests, indicated bilateral symmetry was present between like values in a majority of the skulls. (The only exceptions occurred when comparing the gonial angles within Groups 4 and 5). With this symmetry basically established, it was felt that further analysis was in order. The existence of this symmetry disagrees with the Bolthouse (1970) premise that significant differences do exist between the right and left side of individuals except in the Curve of Spee.

In discussing the significance of the subsequent findings, the number of samples within the groups studied must be considered. (Group 1 contained 33 skulls, Group 2 - 14 skulls, Group 3 - 3 skulls, Group 4 - 5 skulls, and Group 5 - 5 skulls). Findings in Groups 3, 4, and 5, though presumably accurate, must be considered in light of the sample size.

The most significant aspect of the descriptive statistics was the range between the maximum and minimum values for the cuspal angulation. This can be explained by the attrition found in the adult skulls which indicated the adult sample (Groups 1, 2, and 3) were of varying age, from young adult (sharper cusps) to older individuals (abraded, flatter cusps)).

Using a matched sample t-test, bilateral asymmetry was found in the gonial angle comparisons, right side to left side, in Groups 4 and 5. This asymmetry in young (Group 4) and in aged (Group 5) skulls can be attributed to the remodeling which occurs in these two age groups. Such remodeling is due to changes in functional stresses and the accompanying physiological responses that are not necessarily symmetrical in occurrance (Sicher and Weinmann, 1955). Such remodeling changes fall within the normal growth processes (Moffett 1966).

The independent t-tests showed in Group 1 and Group 2 comparisons that there existed a significant difference in the overjet values. Overjet by definition is a horizontal overlap of the maxillary incisors forward to the mandibular incisors resulting in Class II malocclusions. Baume (1950) listed the following causes of overjet: maxillary protrusion or mandibular retrusion, maxillary incisor protrusion, mandibular incisor retrusion, or an excessive maxillary tooth size existing where the maxillary incisors are too large for the corresponding size of the mandibular incisors. This significant difference in overjet is not surprising since it is one of the basic features of a Class II malocclusion.

In Group 1 vs. Group 3, the independent t-test also showed a significant difference to occur in the overjet comparison. These findings confirmed established norms indicating Class III cases have negative overjet for the following reasons: the mandible protrudes, the maxilla retrudes, the mandibular incisors protrude, the maxillary incisors retrude, or an excessive mandibular tooth size exists.

In independent t-tests comparing Group 1 with Group 4, the following differences occurred:

1. Left fossa vs. left fossa showed a significant variance. This may be attributed to the children's skulls undergoing greater change than exhibited by a more stable adult skull (Moyers 1963).

2. The Curves of Spee varied right to right and left to left. This was an anticipated result as the mean value of the Curves of Spee as seen in Table 11 indicated the deciduous or mixed dentition skulls had the flatter Curves of Spee when relating to other groups. This find-

ing supports previous evidence of Hellman (1942) and Bolthouse (1970) which denoted flatter Curves of Spee in children as compared to adults due to delayed eruption of bicuspids or flatter occlusal surfaces of deciduous molars. Also, there is generally less crowding or arch length discrepancy in children with mixed or totally deciduous dentitions.

3. The right gonial angle varied significantly from the right gonial angle. However, the left gonial angles did not differ significantly. This finding concurs with Moyers (1963) who stated that at birth, the shortness of the rami and the lack of alveolar bone give the appearance of an obtuse mandibular angle. As muscle function begins, the gonial angle becomes better defined. The lack of significant difference in the left gonial angle comparison may possibly be attributed to the often found asymmetry during this stage of boney development. This finding was also evident in the matched sample t-tests comparing right gonial angles to left gonial angles.

4. The cuspal angles varied right to right and left to left significantly with the sharper cusps appearing in the younger subjects (Group 4). This was no doubt due to the lesser amount of attrition in the younger dentitions as compared to the older, more mature skulls.

Group 1 compared to Group 5 showed significant difference only in the comparison of the right fossae. This may possibly be due to the asymmetrical changes in the aging individual due to asymmetrical loss of teeth, neuromuscular imbalance, pathology, or degenerative processes.

Group 2, when compared to Group 3, had the following significant differences:

1. Left cuspal angles differed from left cuspal angles. Group 3 showed smaller angles and the resultant sharper cusps in comparison to the larger angles and flatter cusps in Group 2.

2. Overbite to overbite comparisons varied significantly due to the fact that Class II malocclusions have deeper overbites than Class III malocclusions as substantiated by Moyers (1963).

3. Overjet comparisons were found to be significantly different. This was an anticipated finding since one of the basic characteristics of Class III malocclusion is a negative overjet.

The coefficient of correlation tests performed within groups between measurements showed no correlation in the Group 1 (Class I) category. Group 1 (33 skulls) was the largest sample category investigated in this research. Since no correlations between the factors of occlusion existed, this author concludes, as did Ricketts (1950), that isolated cases might lead the clinician to believe many dogmatic statements concerning interrelationships between the factors of occlusion. However, when a large sample, such as this, is studied, there is scarcely a single generalization that holds.

In Group 2, the gonial angle is moderately significantly negatively correlated to the overbite and overjet. This is to say as the gonial angle decreases, the overbite and overjet tend to increase slightly. Also, as the gonial angle increases, the overbite and overjet tend to decrease.

Group 3 showed the fossa had a negative correlation of high significance to the gonial angle and a positive correlation to the cuspal angle. Therefore, if the fossa is deeper, the cuspal angle is larger, and the gonial angle decreases. These findings do not support Bell's (1960) conclusion that shallow fossae go hand in hand with flatter cusps.

Group 3, showing a highly significant positive correlation between the Curve of Spee and the overbite, is typical of this type of malocclusion. In brief, the smaller the overbite, the flatter the Curve of Spee may be. This finding is substantiated by Craddock (1945).

Group 3 showed the Curve of Spee to have a highly significant negative correlation to the overjet. As described by Begg (1971), this finding substantiates contemporary orthodontia that the flatter the Curve of Spee, the greater the overjet.

Group 3 also shows the gonial angle to have a highly significant negative correlation to cuspal angulation. This relation may be explained by the description of a typical Class III case with gonial angle decreasing. The cuspal angulation would be expected to increase to reduce interferences in lateral and protrusive excursions of the mandible.

All correlations found within Group 3 must be evaluated in light of the sample size.

Group 4 showed the glenoid fossa to have a highly significant negative correlation to the gonial angle. This is an anticipated finding as it is reported that children's skulls have shallower fossae and large gonial angles (Moyers 1963).

Group 4 also showed the glenoid fossa to have a highly significant negative correlation to the cuspal angulation. This finding was not anticipated as it was assumed this would be a positive correlation based on the mean values of the variables. Children's fossae are shallow and cuspal angulation in the lower molar is at its smallest degree upon eruption. It was assumed that as the fossa depth increased, so would the cuspal angulation.

Group 4 showed the Curve of Spee to have a moderately significant positive correlation to overbite and a highly significant positive correlation to overjet. This finding is in keeping with the observation that children up to age 8-10 years undergo a period in which a naturally occurring Class II situation arises, accompanied by a severe Curve of Spee, deep overbite, and excessive overjet (Moyers 1963).

Group 4 also showed the gonial angle to have a moderately significant positive correlation to cuspal angles. This was an anticipated finding as large gonial angles and larger cuspal angles (prior to attrition) are characteristic of younger individuals (Begg 1971).

No correlations existed within Group 5.

This research was an attempt to determine if a mathematical interrelationship existed between the various factors of occlusion. In the majority of comparisons no significant correlation existed between the measurements.

It was anticipated that more correlations between the factors of occlusion would exist, especially those involving the temporomandibular joint (depth of fossa) and the occlusion. Due to the absence of such correlations, the previously derived conclusions become subject for discussion, for example that of Stuart and Stallard (1964). "In the main, the cusp height and fossa depth are determined by the steepness of the eminences down which the condyles travel and the vertical trend of the working condyle when being thrust laterally."

The significance of this research is the resultant questioning of the validity of established rules as put forth by clinicians of the various dental specialties, namely the assumption that all factors of occlusion are interrelated mechanically. Perhaps too much emphasis is placed on this theory and insufficient thought given to the adaptability of the neuro-muscular complex as the compensatory mechanism which affords harmonious utilization of the masticatory apparatus even though certain factors of occlusion are out of "balance." In 1946, Robinson expressed the opinion that the muscles are almost solely responsible for the intricate movements of the mandible.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This research was designed to attempt to determine if an interrelationship exists between the depth of the glenoid fossa, the severity of the Curve of Spee, the cuspal angle, the gonial angle, and the degree of overbite and overjet.

Sixty dry skulls were used in this project: fifty adult skulls with permanent dentitions, five children's skulls with mixed or deciduous dentitions, and five skulls of the aged, edentulous category.

Laminagraphic X-rays were taken of these skulls with a plane of cut through the temporomandibular joint and the long axis of the body of the mandible. Using these X-ray films, acetate tracings were made of the glenoid fossa, the anterior and posterior eminences, the distal border of the ramus, the inferior border of the body of the mandible, and the Curve of Spee on the mandibular cusp tips of all teeth present in each film. From these tracings angular or linear measurements were made of the aforementioned area of study with a protractor or caliper. The measurements were then recorded in degrees or millimeters.

The overbite and overjet was measured directly on the dry skulls at the midline as determined by the maxillary and mandibular incisors. These measurements were obtained by using a bow divider and the same caliper used in the measurements on the acetate tracings.

Supplemental data was collected on the dry skulls by directly measuring the medial-lateral width of both the mandibular condyles and the glenoid fossae. These measurements may possibly relate to other factors of occlusion and were entered into the data as it was programmed.

It is difficult to compare mathematically the interrelationships between two or more structures due to the non-existence of devices, instruments, or techniques to more precisely take measurements. For this reason, great care was utilized in gathering the data to adhere to the decided-upon method and achieve maximum uniformity in light of these limitations.

All data was computer processed. Computer punch cards were made up for each skull with its fourteen variable measurements. The skulls were then categorized by groups.

Group 1 - Adults with Class I occlusion.

Group 2 - Adults with Class II malocclusions.

Group 3 - Adults with Class III malocclusions.

Group 4 - Children with mixed or deciduous dentitions.

Group 5 - Aged skulls of the edentulous category.

Descriptive statistics for the entire sample were obtained as well as mean values for each measurement within each group. Matched sample T-tests were utilized to compare the findings within a group as to right vs. left side. Independent T-tests were then employed to compare the variables between the various groups.

Coefficient of correlation tests were performed to ascertain if a relationship existed between the variables in this study. These tests were run within each group and attempted to relate the glenoid fossa with the Curve of Spee, fossa with gonial angle, fossa with cuspal angle, and fossa with overbite and overjet. They also related the gonial angle with the cuspal angle and overbite and overjet.

No correlations were found in Groups 1 and 5. Group 2 had two correlations relating gonial angle to overbite and overjet. Group 3 had five correlations relating fossa to gonial angle, fossa to cuspal angulation, Spee to overbite, Spee to overjet, and gonial angle to cuspal angle. Group 4 had five correlations: fossa to gonial angle, fossa to cuspal angle, Spee to overbite, Spee to overjet, and gonial angle to cuspal angulation.

The author concluded the following based on this research:

Bilateral symmetry does exist between right and left side as to the measurements compared in this study except for gonial angles in Groups 4 and 5.

Certain definite relationships were found involving fossa, gonial angles, cuspal angles, overbite, overjet, and the Curve of Spee within Groups 2, 3, and 4. This author concludes, however, that a study of larger sample sizes is indicated to further substantiate these findings.

The majority of the evidence found in this work pointed to the relatively high degree of independence between all factors of occlusion examined. This finding supports Todd's (1930) contention that "form does not slavishly follow function," and corroborates Angel (1948) concerning morphologic development when he stated that "genes appear more important determinants than environment."

Extreme emphasis has been placed on the clinical appearance of the many factors of occlusion and perhaps too many diagnoses have been made attempting to interrelate the various factors. This author concludes that the reliance on traditionally assumed interrelationships between the factors of occlusion may lead the clinician in an erroneous direction.

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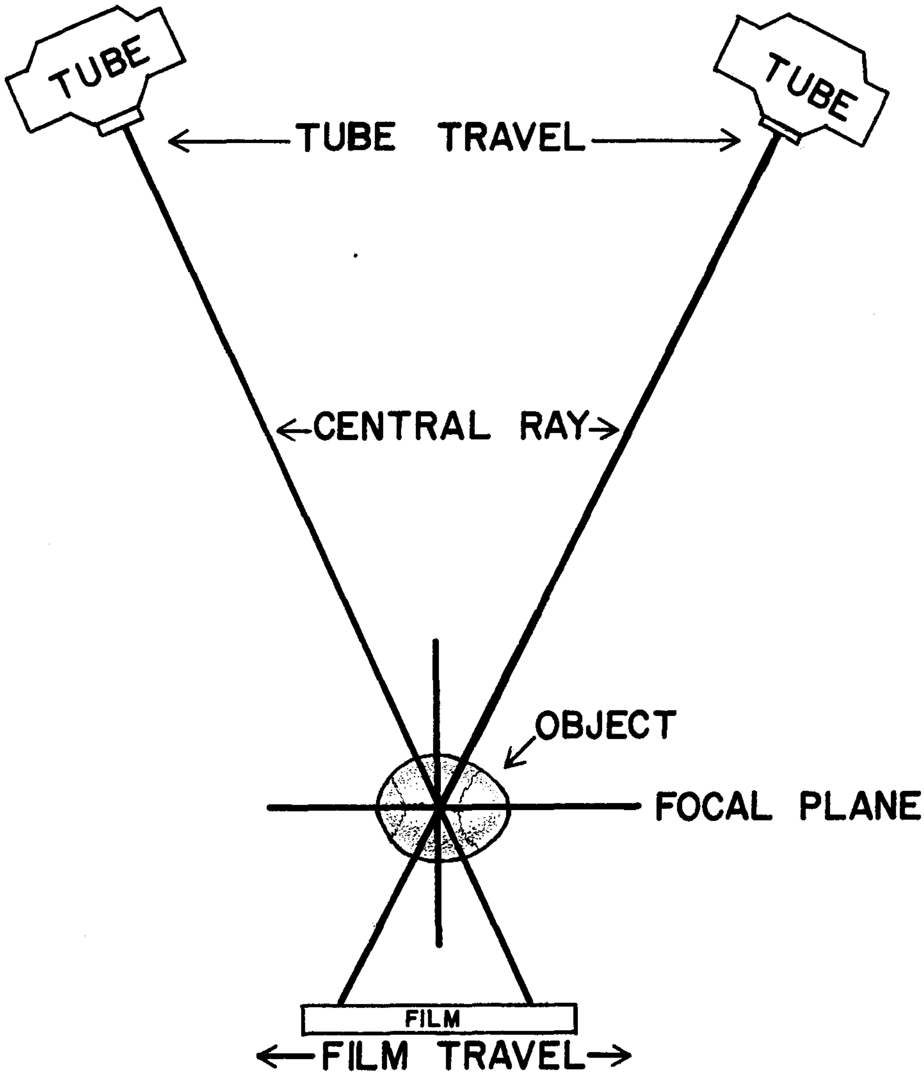
APPENDIX

Radiography is one of the most important diagnostic tools available to the clinician. No other means records physiological phenomenon as accurately. However, superimposition of structures over the areas of study often confuses or misleads the practitioner. It is in the reduction of this problem that laminagraphy excels over conventional radiography.

Laminagraphy is a method that permits radiographic projection of plane sections of solid objects in a predetermined plane or depth, thus eliminating many of the structures which would show up in conventional X-ray as superimpositions.

The manner in which a laminagraph is produced is as follows: The point of emission of X-rays moves in one direction while the film or recording medium moves in the opposite direction. The tube and the film move simultaneously in a constant relationship that is maintained by a connecting system which rotates about an axis lying in the plane of the section to be projected. (Figures 2, 3, 4, 15) Planes other than the plane of the section to be projected experience relative displacements on the film and are blurred. The degree of blurring depends on



Principles of Laminagraphy

FIGURE 15

the distance of the other planes from the projected plane. The further the other plane is from the projected plane the faster the image travels across the film, hence the greater the blurring. Conversely the closer the other plane is to the projected plane the slower its image will travel across the film producing a lesser amount of blurring. Consequently the most finely focused plane is the plane of projection and this plane always lies in the same plane through which the axis of both the film and the tube pass.

Early laminagraphy was referred to as body-section radiography and was described by Bocage (1932). Its main use at that time was in clinical evaluation of the chest in medical diagnosis. Ott, Portes, and Chausse (1935), also Europeans, suggested a method of applying its use in deep roentgen therapy for concentration of depth dosage. Vallebona was one of the first to put this method to use in making body-section radiographs, referred to by him as "stratigrams." His method rotated the object and the film and tube were held constant. Siemens and Reininger constructed a research model of a planigraph instrument in 1934. Kieffer (U.S.A.) and Grossman (Germany) both claimed to discover this technique and debated this fact for some time. Grossman's product was called the

Tomograph and was built in 1935. Kieffer's model (1936) was refined by Moore who called his instrument the laminagraph (thin lamina layers).

The University of Illinois uses an "ordograph," a laminagraphic unit with a tilt table allowing laminagraphs to be taken in several positions. This unit is manufactured by the General Electric Company and is Model No. 11GE3.

At Loyola University, laminagraphy of the temporomandibular joint is performed by the Quint Laminagraphic Cephalometer. The ear rods are inserted reciprocally into the auditory canal of the patient and the head is positioned rigidly with the Frankfort plane parallel to the floor. The patient's head is rotated 20° to the side of the temporomandibular joint being X-rayed. The focal point is approximately 3.5 cm. distal to the midpoint of the skull. The object-film distance is approximately 15 cm. The tube-target distance is five feet and the exposure time is 1.25 seconds. These settings can vary slightly due to trial and error used in obtaining the best possible films when skeletal abnormalities and asymmetries exist.

DATA SHEET I RIGHT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
01	4	7.20 mm.	.90 mm.	125	96
02	4	7.10	1.10	128	86
03	4	3.35	1.00	139	134
04	4	5.00	.37	128	130
05	4	6.35	1.30	129	91
01	5	6.35		132	
02	5	4.00		129	
03	5	6.00		121	
04	5	6.35		116.5	
05	5	5.00		118	
01	1	5.25	2.90	121.5	100
02	1	6.70	4.60	112	138
03	1	5.35	2.65	138	115
04	3	5.30	2.20	125	114
05	1	6.80	3.20	112	123
06	1	7.40	2.80	119	95
07	1	8.45	1.20	117	113
08	1	6.50	1.60	112	117
09	2	4.65	1.22	134	129
10	2	4.85	4.00	116	106
11	1	6.90	3.25	117	132
12	3	6.35	1.20	121.5	112
13	1	7.50	1.10	118.5	104.5
14	1	5.50	1.20	125.5	126.5
15	1	4.80	3.35	121	137

TABLE 1

DATA SHEET II RIGHT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
16	1	6.50 mm.	2.35 mm.	121	135
17	1	6.55	2.00	117	150
18	2	4.75	2.55	116.5	137
19	1	4.80	2.20	117	152
20	1	5.80	2.65	120	127
21	1	6.00	2.70	117	121
22	1	7.10	2.40	124	129
23	1	5.40	1.65	119	114
24	2	5.45	1.60	104.5	130
25	1	6.85	2.20	123	114
26	2	8.30	-.65	121	138
27	1	6.50	1.55	115	125
28	1	7.35	1.60	113.5	135
29	1	8.45	2.80	121	119
30	2	6.60	4.10	120	143
31	1	6.40	1.55	120	134
32	1	6.90	1.85	118	136
33	1	8.20	1.50	115	135
34	2	6.15	3.35	121.5	121
35	2	5.30	1.50	121	144
36	2	5.80	2.50	109.5	139
37	1	6.75	3.55	115.5	116
38	1	7.40	1.85	126.5	121
39	1	7.15	.65	118.5	138
40	1	7.15	2.35	104.5	108

TABLE 2

DATA SHEET III RIGHT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
41	2	6.90 mm.	2.10 mm.	127	110
42	1	5.90	1.50	130	108
43	1	6.45	3.15	118.5	110
44	2	7.65	1.20	116	109.5
45	2	8.00	3.60	103.5	110
46	2	9.10	.70	115.5	138.5
47	1	8.25	4.30	127	146
48	3	8.85	3.05	120	133.5
49	1	7.45	2.30	120.5	140
50	2	7.50	1.65	115	134.5

TABLE 3

DATA SHEET IV LEFT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
01	4	6.85 mm.	.65 mm.	122.5	101
02	4	6.95	.40	121	85
03	4	2.20	.75	133.5	106
04	4	5.30	.90	123	97
05	4	4.48	1.30	123	115
01	5	7.50		126	
02	5	5.90		128	
03	5	5.45		118	
04	5	6.00		112.5	
05	5	5.60		117	
01	1	5.85	1.80	119	112
02	1	7.10	2.95	100	130
03	1	4.70	1.40	136	90
04	3	7.00	2.30	129	103
05	1	6.50	2.65	103	112.5
06	1	7.55	2.70	116.5	110
07	1	10.20	2.80	115	162
08	1	6.25	1.20	115	136
09	2	3.80	1.40	133	143
10	2	4.25	3.20	115	127
11	1	6.00	2.70	113	110
12	3	6.20	.80	123	121.5
13	1	6.45	.95	114	115.5
14	1	5.10	2.00	127	130
15	1	4.85	3.20	123	140

TABLE 4

DATA SHEET V LEFT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
16	1	6.25 mm.	2.30 mm.	125	135
17	1	6.75	3.50	116	146
18	2	4.40	1.10	120	138.5
19	1	6.30	3.00	120	147
20	1	5.85	3.20	120	144
21	1	7.35	3.25	116	110
22	1	7.10	3.00	126	109
23	1	5.70	4.45	116.5	142
24	2	5.70	1.60	104	142.5
25	1	8.15	2.50	117.5	124
26	2	8.90	2.20	119	108.5
27	1	8.05	-.35	117	132
28	1	6.00	3.00	113.5	143
29	1	8.00	3.20	123.5	136
30	2	6.40	3.95	122	141
31	1	5.95	1.35	121	126.5
32	1	6.70.	.55	121	147
33	1	8.40	3.00	115	141.5
34	2	6.75	3.65	126	114
35	2	5.90	1.85	119	133.5
36	2	5.90	3.35	112	133
37	1	6.05	2.50	109	135.5
38	1	5.00	2.75	130	141
39	1	7.30	1.60	120	121
40	1	5.85	2.45	106	135

TABLE 5

DATA SHEET VI LEFT SIDE MEASUREMENTS

Skull	Gp.	Fossa Depth	Curve of Spee	Gonial Angle	Cuspal Angle
41	2	8.00 mm.	.75 mm.	125	139
42	1	5.95	.55	127	110.5
43	1	7.65	1.10	123	125.5
44	2	7.25	3.55	117	147
45	2	7.40	2.85	109	137
46	2	8.00	2.30	116	113
47	1	6.75	2.45	124	149
48	3	6.20	1.30	115.5	111
49	1	8.00	2.50	116	135.5
50	2	5.70	3.55	112.5	123

TABLE 6

DATA SHEET VII OVERBITE AND OVERJET MEASUREMENTS

Skull	Gp.	Overbite	Overjet
01	4	1.55 mm.	2.50 mm.
02	4	2.55	1.70
03	4	2.65	1.30
04	4	0.00	0.00
05	4	2.75	3.40
01	5		
02	5		
03	5		
04	5		
05	5		
01	1	2.70	0.00
02	1	2.35	.80
03	1	2.45	.45
04	3	0.00	-3.00
05	1	3.30	.80
06	1	.90	0.00
07	1	1.10	0.00
08	1	-1.00	-2.00
09	2	-1.00	0.00
10	2	3.90	0.00
11	1	-1.00	.50
12	3	- .35	- .40
13	1	.65	0.00
14	1	-1.40	4.00
15	1	2.25	1.30

TABLE 7

DATA SHEET VIII OVERBITE AND OVERJET MEASUREMENTS

Skull	Gp.	Overbite	Overjet
16	1	1.00 mm.	0.00 mm.
17	1	- .40	.90
18	2	0.00	2.60
19	1	-4.15	5.50
20	1	.70	0.00
21	1	2.25	1.90
22	1	1.75	.80
23	1	3.40	3.70
24	2	4.35	2.70
25	1	2.00	0.00
26	2	1.75	.80
27	1	2.40	.45
28	1	1.10	.65
29	1	- .60	-3.00
30	2	2.40	4.10
31	1	1.35	1.85
32	1	0.00	1.00
33	1	0.00	.75
34	2	1.45	1.35
35	2	1.60	0.00
36	2	2.05	4.10
37	1	.65	0.00
38	1	0.00	3.30
39	1	4.05	.85
40	1	3.00	1.35

TABLE 8

DATA SHEET IX OVERBITE AND OVERJET MEASUREMENTS

Skull	Gp.	Overbite	Overjet
41	2	2.20 mm.	2.65 mm.
42	1	.50	.60
43	1	1.05	.90
44	2	2.95	1.85
45	2	2.35	3.80
46	2	0.00	1.60
47	1	1.50	1.55
48	3	0.00	-3.00
49	1	.65	.10
50	2	1.70	1.65

TABLE 9

APPROVAL SHEET

The thesis submitted by Dr. Edwin C. Liedtke has been read and approved by members of the Departments of Anatomy and Oral Biology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

5/16/72

Date

William A. Malone

Signature of Advisor