A Detailed Consideration of the Line of Occlusion

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The origin of the concept of the "line of occlusion" is not clear. Writings prior to Edward H. Angle emphasized "irregularities" of the teeth. This implied a "regular" organization or a systematic, normal arrangement of teeth. The word "alignment" began to appear along with the notion of "malalignment." Alignment probably became Angle's underlying objective in his teaching of the "line of occlusion" as he classified malocclusions.

Originally, two lines were considered, one for each arch. By 1906 Angle described the line as "the line of greatest normal occlusal contact." But in 1907 he redescribed it as "the line with which in form and position, according to type, the teeth must be in harmony if in normal occlusion."[1]

The word "harmony" implies parts combined in an orderly agreement or unison. The line of occlusion, Angle said, was intended to govern the length, breadth, and curve of the arches, the pattern of teeth and their positions relative to skeletal parts, according to inherited type. Angle concluded that there could be but one true line of occlusion, and it must be the *same* as the architectural line upon which the dental apparatus was constructed. The line, twenty years later, became somewhat involved with the word "idealism" as Angle sought to reach a perfected alignment of teeth with the ideal arch with his edgewise mechanism.

The interpretation of Angle's intended use of the line of occlusion, however, became confusing. Some believe Angle was thinking of a line through the contact points as used for calculating arch length. Others imagined a line through the centers of the crowns, while still others used a line at the middle of the buccal surface at the circumference of each arch, such as would be necessary for the archwire attached to brackets.

The concept of a curved "line of occlusion" becomes more complicated when confused with a straight "occlusal plane," viewed from the lateral headplate. The use of a bisection of the overbite of maloccluded incisors for that determination was also misleading as it was followed later by the "true buccal occlusal plane" selected by the overlap of the buccal occlusion. When the curve of Spee and curve of Wilson are added, a bewildering problem in semantics becomes obvious (Fig. 1).

It was Angle's viewpoint that the lower arch should be the foremost concern in orthodontics. He observed the lower arch as a base upon which the upper arch is molded. By the biologic process of earlier eruption of the lower teeth followed by the action of the incline planes, under the influence of muscle, the normal occlusion develops. He inferred that the lower arch be set

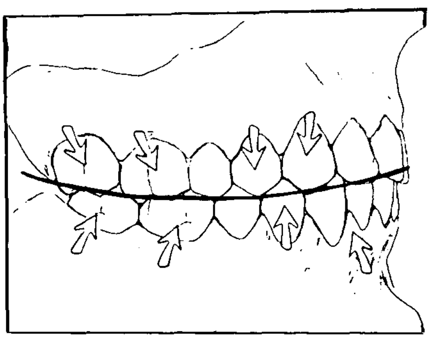

Fig. 1 The line of occlusion visualized laterally as a line through the overlap of the buccal cusps and incisal edges of teeth. The arrows represent the direction of the eruption and forces of the incline planes as described by Angle.

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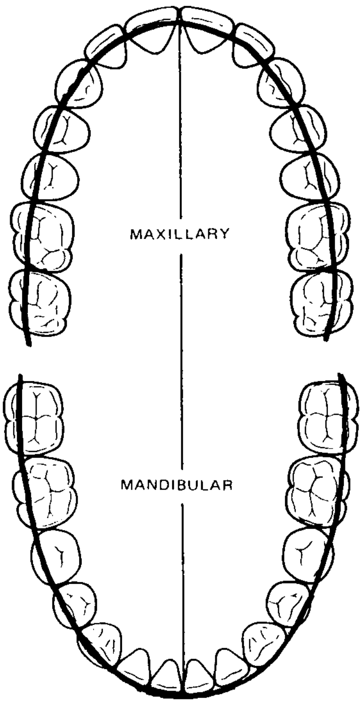

Fig. 2 The imaginary line through the labioincisal and bucco-occlusal contact of the teeth representing the interpretation of Angle's line of occlusion.

up as a basis to which the upper teeth be corrected. This implied a significance to the position of the lower arch relative to skeletal parts. This is of importance conceptually to the reciprocity of the lower incisor between the jaws. Intuitively, Angle also probably respected the dominant role mandibular growth plays in development.

Angle's writings further seemed to display an underlying theme: the interdependence of teeth. He described the action of inclined planes as a double mortar and pestle system. He pointed out the interlocking of teeth to take place so that, in normal development, "the teeth work toward harmony and the arches function together to promote, secure, and stabilize the occlusion rather than to force teeth out of normal position." In a modern sense this perhaps is referred to as "tripodization" with regard to function so that deflections are minimized and occlusal function is not traumatic or detrimental to the supporting apparatus.

From a contemporary logical deduction of Angle's concept and if there is but one true line, it must be at the occluding surfaces of the teeth and not through the contacts of the individual arch. No doubt each arch considered independently must possess its own integrity. But as they contact for centric stability, the "line" must surely be a common meeting place for unison and synchronization (Fig. 2).

Scientific Analysis of Occlusion: Orientation in Three Directions

It is convenient to start a detailed study of normal occlusion with the analysis of the relation of each individual tooth. This would mean a consideration of (1) occlusal stops against antagonists, (2) the vertical tooth-to-tooth or height relationships, (3) the rotational aspects of each tooth, and (4) the axial inclination of each tooth in a mesiodistal and buccolingual direction. Analyzed in the foregoing manner, the study of a line of occlusion becomes a line through the proximal contact points of the individual arches with considerations of arch synchronization as the final determinant (Fig. 3).

But Angle, in his discussion of the line of occlusion, was even more inclusive and referred to the need for considering the position of the entire denture. He mentioned the significance of teeth to the rest of the body as a whole which included skeletal type, muscle type, and even individual personality or temperamental type. Thus, the reciprocal location of the entire occlusal platform was to be a part of the concern with the line of occlusion.

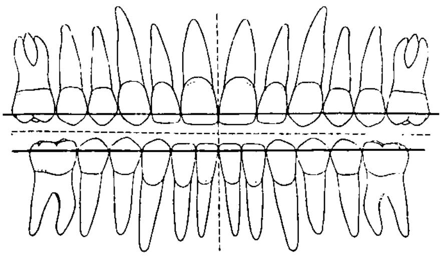

Fig. 3 A concept of three lines of occlusion as a working hypothesis for orthodontists. The solid lines represent common lines through the contacts at marginal ridges and anterior embrasure spaces. The dotted line represents the common meeting place of the teeth.

Variation in Form and Function

A study of any aspect of orthodontics immediately involves the problem of variation in the size of structure, variation in the form of parts, and variation in function. In fact, Angle included eight variables in occlusion which were: position, interincisal relation, size of teeth, pattern of teeth, length of cusps, width of arch, arch form, and curve of Spee. Case also recognized variation when he wrote, "the terms 'normal' and 'anatomic' mean 'according to rule,' or 'in conformity to natural law' . . . they are useful words because variations from the typical are the rule."[2]

The biologist thinks not in terms of a finitely defined norm; instead, he imagines a normal range. The scientist always is faced with the curve of distribution. The clinician's job is to determine the peak of the curve of normal distribution as a concept of an imaginary ideal and then work with exceptions from that rather than starting from some arbitrary unknown and working without basic ideal concepts. Therefore, the objective to be employed for mechanical procedures is to perceive the "ideal" and determine its characteristics and then work from the peak both ways so that differences from that ideal may be dealt with as harmony and balance (equilibrium) become the goal.

In many patients secondary factors may alter absolute ideal objectives. *Skeletal* parts may not be harmonious or in good proportion, and this will mean appropriate compromises are indicated from otherwise ideal relations. Also, *functional* problems may alter the oral environment when muscle structure itself may be inadequate, or *psychologic* factors may be present causing prolonged habits. Beyond this, *discrepancies* in tooth size and tooth form may alter an otherwise harmonious situation.

In addition to the previous factors, excessive changes are required for the overcoming of inherent genetic and environmental conditions, for the problems encountered by altering normal relations for the purpose of securing anchorage, and for avoiding the excessive counter positions for overtreatment. All are compounding factors. Another factor is the need to produce conditions or positions of teeth which will better resist relapse. Consequently, the idea of absolute idealism is modified when all of these clinical factors are taken into account.

Line of Occlusion, Location and Position

Because Angle emphasized "position" again and again, let us relate studies conducted for the determination of the nature of the curve of distribution for the prominence of the denture. As protrusion is considered, the center or boundaries of skeletal parts serve as reference. These are point A in the maxilla and pogonion in the mandible. A sample of 82 normals selected by members of the Foundation for Orthodontic Research showed that the mean position of the tip of the lower incisor to the APo plane was 2.4 mm ± 2 mm.[3] Seventy percent would fall between 0 to 4.0 mm (Fig. 4). This would mean

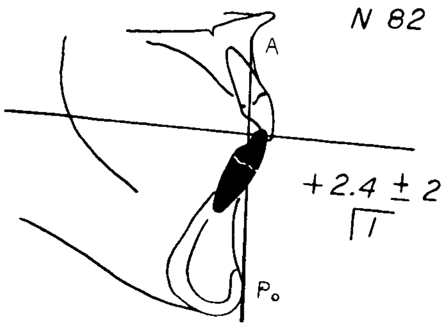

Fig. 4 The findings in 82 normal cases from the Foundation for Orthodontic Research revealed a mean of 2.4 mm ± 2 for the lower incisor position to the APo plane. This is commonly used to evaluate the position of the lower denture relative to the denture base.

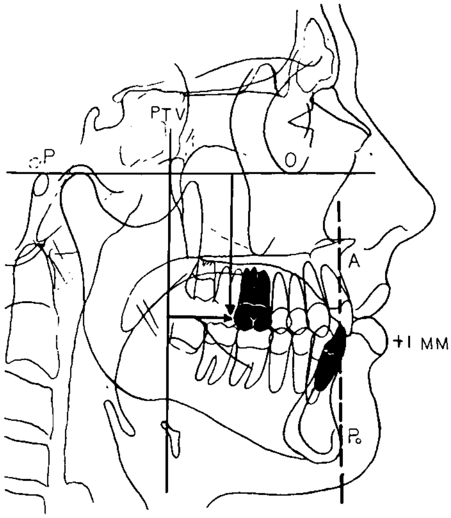

Fig. 5 The lower incisor is more upright in an 18-year old untreated male. The author's hypothesis clinically is 1.0 mm ± 2.0 mm to the APo plane. The horizontal parameters are PTV and APo. The upper first molar was highly correlated with the vertical position measured from the Frankfort plane and the horizontal measured from the pterygoid vertical.

essentially that the lower incisor of only one "normal" patient in 13 protrudes from 5 to 6 mm. The chances are a like number will therefore retrude behind the APo plane.

The author's working hypothesis in orthodontics for many years has been +1 ± 2 mm with variations being determined by facial type and lip flaccidity[4] (Fig. 5). The position of the upper first molar to the Frankfort and pterygoid vertical was found also to be responsive to the aggregate of the facial type as it was the most frequently associated measurement in computer studies including 362 measurements. This would tend to support Angle's reasoning.

The vertical location of the line of occlusion also bears a relationship to skeletal parts. Studies of the true buccal plane representing the bucco-occlusal contact have shown that the line biologically is roughly associated with the Xi point (or the centroid of the ramus) which approximates the functional movement center of the mandible as well as the entrance of the mandibular nerve into the mandible[5] (Fig. 6). Skeletally, the vertical location of the occlusal plane from the oral gnomic orientation is 47 percent in the upper

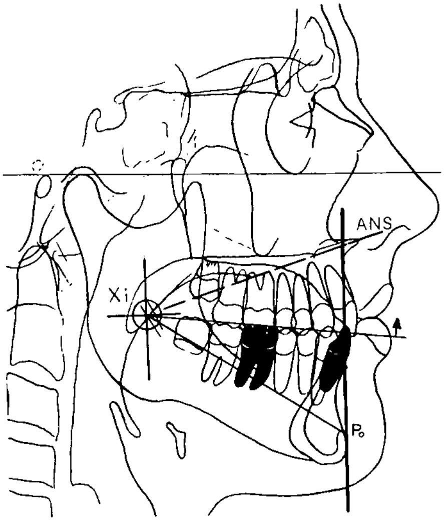

Fig. 6 The occlusal plane has a high order to the Xi point, the lip embrasure and the corpus axis as demonstrated here. These three parameters are employed for vertical location. The vertical parameters are stomion and the Xi point.

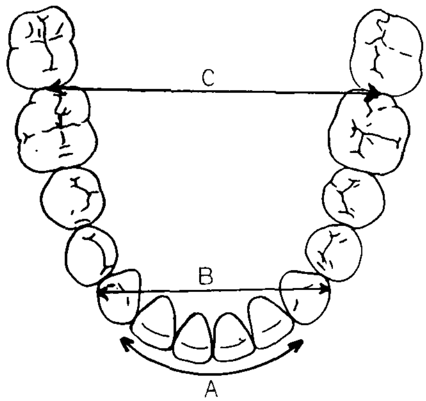

Fig. 7 The biparameter catenary curve for mathematical calculation of the lower arch as developed by Schulhof. The width of the anterior teeth (A), a measurement at the distal of the canines (B), and the width of the molars (C) are employed for this calculation which predicts variation in the arch form.

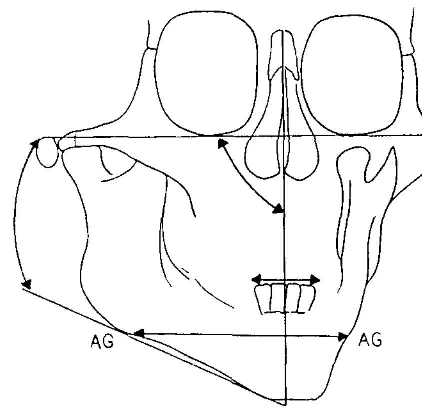

Fig. 8 Factors in the determination of arch length were found to be related in the individual to the Ag points combined with the lower incisor width, the facial angle, and the mandibular plane angle (From Schulhof—RMDS).

and 53 percent of the total denture height angle (ANS-Xi-Pm) for the lower (Fig. 6).

Line of Occlusion, Arch Form

With the position of the denture measurable in three dimensions, the last consideration is arch form. Angle referred to the variation needed from the Bonwell-Hawley method but was limited other than emphasizing the need for intuitive guessing for inherited type. Arch form remained enigmatic until mathematical formulas were derived from treated normal and stable cases. Brader[6] first lent credence to mathematical relations with the theory of a trifocal ellipse, particularly useful for the upper arch.

From clinical data Schulhof[7] designed a biparameter catenary curve for the lower arch as a basis for estimating *individual* arch form based on anterior tooth size, arch width at molars, denture position, and individual skeletal framework. The measurements from the distal of the canines and the intermolar width were factors added with anterior tooth size (Fig. 7). As these were coupled with factors in the skeletal relations, predictions of arch form could be accomplished (Fig. 8). Thus the diameters or size of teeth are taken into account in the determination of the line of occlusion, and tooth-size discrepancy becomes a factor.

The width of the denture at the lower first molar is measured from the skeletal parts associated with the basal bone, J point in the maxilla and the Ag point on the mandible (Fig. 9). The lower molar erupts at age 6 at 5 mm ± 2 from the JAg line.[8] Growth change results in a measurement of 6 mm ± 2 by age 8 going to 10 mm ± 2 in the adult female with larger values, corrected for size, in the males. Thus, arch width is associated with skeletal type when appropriate skeletal references are used.[9,10]

Other factors found useful were the bend of the mandible, the length of the corpus, and the cant of the mandible in the face[11] (Fig. 10). All of these factors of growth and treatment objectives and arch position, location, form, and size are now also computerized.

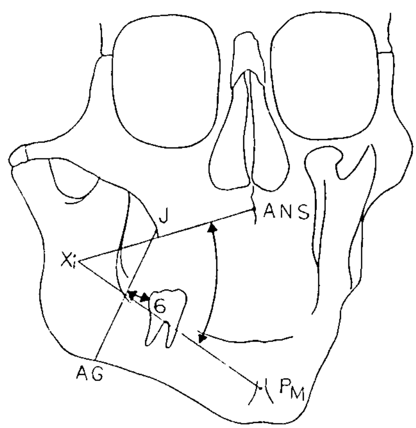

Fig. 9 Factors in arch width were found to be associated with the width of the maxilla compared with the mandible, or line JAG. It was also found to be associated with the oral gnomon, or ANS-Xi-Pm.

Line of Occlusion, Congruity Factors

If one common functional line is accepted as the line of occlusion, certain factors alter the consideration for the individual. These influence the interincisal, intercanine, and intermolar relations. Tooth patterns such as shovel-shaped incisors, peg-shaped laterals, or general crown and root form may alter overbite and overjet as well as cusp height. Tooth form may also influence the functional fitting of the teeth. Consideration of studies relative to these

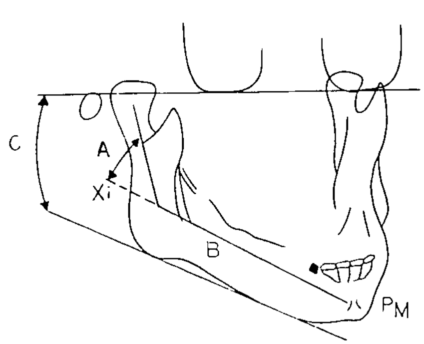

Fig. 10 The bend in the mandible (A), the length of the corpus axis (B), and the cant of the mandible (C) are predictive factors.

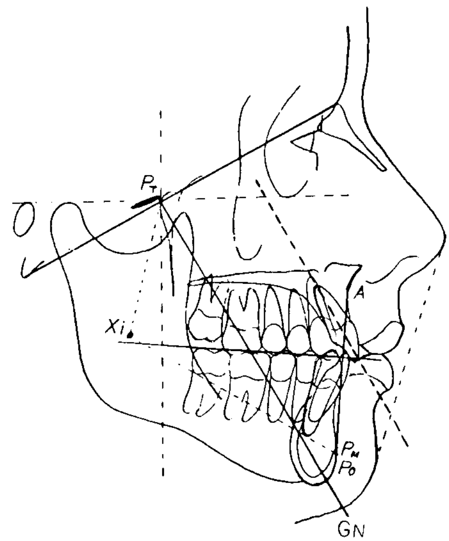

Fig. 11 Studies of stability of treated cases suggest an interincisal angle of 125°. This usually requires the lower incisor to be canted 16° and the upper incisor 39° to a vertical to the occlusal plane. Note parallelism of the upper incisor angulation with the facial axis (PtGn). The more forward the facial axis, the more inclined the upper incisor. Thus the lower incisor is oriented to point A and the upper is oriented to the chin.

factors have shown means and deviations in certain of these factors.

As a working hypothesis, a 2 mm *overjet* and *overbite* is the aim. The SD is ± 2 mm but the variation is 0 to 5 mm. The *interincisal angle* also has been controversial; however, studies on stability of treated cases suggest a relation of 125° ± 5° to be the most secure. The upper incisor also is found to be essentially parallel with the facial axis[12] (Fig. 11).

Due to more prominent cusps, the overbite of canines in 20 normals measured 3 mm ± 1 mm. Small samples of good occlusions suggested an intercanine angle of 135° as measured from 45° oblique head films on the opposite side. However, large sample studies have not been conducted for this measurement.

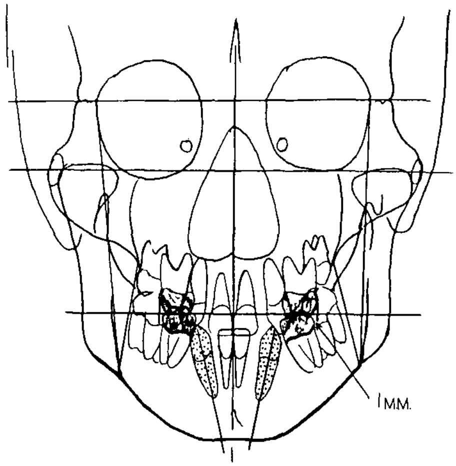

Fig. 12 The upper molar overhangs the lower molar in the frontal view 1 mm ± 1 mm. The ideal canines diverge at the crowns and converge at the roots in the frontal perspective in this 18-year old male.

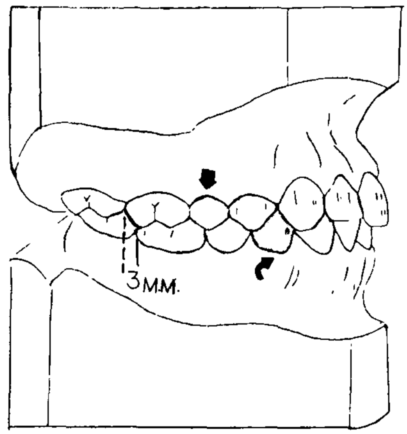

Fig. 13 Tracings of casts of a normal 13-year old male suggest ideal relationships in which the distal incline of the upper first molar is in contact with the mesial-buccal cusp at the lower second molar requiring 3 mm of distal position to the distal margin of the lower molar. The upper second premolar is similarly locked into the inner space between the lower first molar and the lower second premolar. The lower first premolar is located well to the buccal in contact with the distal incline of the upper canine.

Computer studies of the normal occlusion sample confirmed an upper molar buccal overhang of the lower molar at 1 mm when measured cephalometrically from the buccal surface contour (Fig. 12).

Analyses of the most ideal occlusions show the upper molar to be 3 mm distal to the lower molar. The clinical deviation for purposes of analysis in malocclusions is ± 3 mm. This brings the normal variation up to an end-to-end relation. Actually, for strictly ideal molar relation, this SD hypothetically should be ± 1 mm.[13] This condition, guided by the first molar occlusion, produces an interlocking of the upper premolars into the corresponding interspaces of their antagonists below. It is felt that this relationship produces the most efficient, most self-cleansing, and most self-preserving relationship according to nature's plan (Fig. 13).

Orthodontists are accustomed to recognizing and utilizing the function of the inclined planes of the cusps of the teeth. During growth and following treatment, the teeth are observed to wedge into final position by force of eruption and forces of occlusion (see Fig. 1).

Occlusal Centric Stops

While the general incline relations are observed, the practitioner is often chagrined to find the detail relation of the teeth is often not in the kind of contact or function assumed by the gross appearance. Recognizing this predicament, the author made a study of the ideal cases at his disposal and made "occlusogram" studies on about 200 consecutively observed cases in retention. The result was a plan with the number of contact stops (Fig. 14) from the incisor posteriorly and the lingual to the buccal, taking into account variation as nature never completely duplicates form.

The ideal with third molars present came up to 30 stops on each side, yielding a total of 60 points of contact of

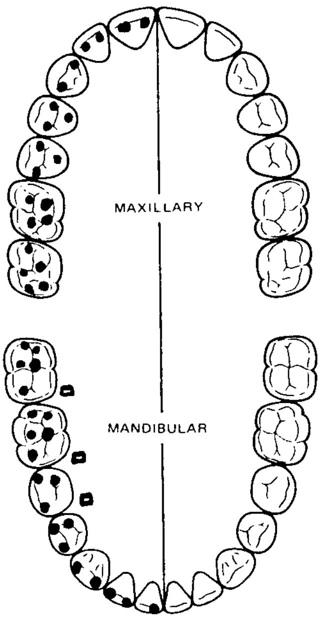

Fig. 14 Occlusogram studies suggest this normal pattern of occlusal stops. The spots represent common occlusal stops and Angle's line of occlusion would thus be a line through the most buccal contact stops. The square marks at the lingual are optional possible contacts dependent on rotations of teeth. The buccal posterior contact stops are even numbered and the lingual stops are odd numbered. Twenty-four stops are possible.

the lower against the upper in centric stops. Reducing six for missing lower third molars, a total of 24 were identified. Optional contacts for rotated premolars make two less, and a weak distolingual cusp of upper first molar another, so actually 21 is more realistic. If a premolar is extracted, the centric stops are now reduced to 18. Therefore, missing third molars and premolars reduce total contact from 60 to 38 or 40, about one third of the total vertical platform. In some of the author's patients, thought clinically to be in good relation, as few as eight contact stops per side were noted. This finding was quite disturbing and led to greater attention to finishing and "settling."Producing conditions under which the teeth would settle into better occlusion rather than settling out of occlusion became an important consideration. Thus, the even-numbered contacts in the posterior teeth simulate the presently-held concept of the line of occlusion.

Summary

With the re-evaluation of the concept of the "line of occlusion" the author proposes a contemporary definition: "a distinctively individual line at the incisobuccal contact, with a location, position, and form to which the teeth must conform to be in normal occlusion." In other words, it is that position which the teeth must occupy to be in stability and harmony with each other and with all other anatomic structures.

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