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ORIGINAL ARTICLES

A CONSIDERATION OF NORMAL AND ABNORMAL DENTURES AS A PROBLEM OF THREE DIMENSIONAL SPACES AND ITS BEARING ON ORTHODONTIC CLASSIFICATION AND TERMINOLOGY*

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“OF THE chemistry of his day and generation, Kant declared that it was ‘a science, but not science,’—‘eine Wissenschaft, aber nicht Wissenschaft;’ for that the criterion of physical science lay in its relation to mathematics. And a hundred years later Du Bois Reymond, profound student of the many sciences on which physiology is based, recalled and reiterated the old saying, declaring that chemistry would only reach the rank of science, in the high and strict sense, when it should be found possible to explain chemical reactions in the light of their causal relation to the velocities, tensions and conditions of equilibrium of the component molecules; that, in short, the chemistry of the future must deal with molecular mechanics, by the methods and in the strict language of mathematics, as the astronomy of Newton and Laplace dealt with the stars in their courses. We know how great a step has been made towards this distant and once hopeless goal, as Kant defined it, since van’t Hoff laid the firm foundations of a mathematical chemistry, and earned his proud epitaph, *Physicam chemiae adiunxit*.

“We need not wait for the full realization of Kant’s desire in order to apply to the natural sciences the principle which he urged. Though chemistry fall short of its ultimate goal in mathematical mechanics, nevertheless physiology is vastly strengthened and enlarged by making use of the chemistry,

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as of the physics, of the age. Little by little it draws nearer to our conception of a true science, with each branch of physical science which it brings into relation with itself; with every physical law and every mathematical theorem which it learns to take into its employ. Between the physiology of Haller, fine as it was, and that of Helmholtz, Ludwig, Claude Barnard, there was all the difference in the world.

“As soon as we adventure on the paths of the physicist, we learn to weigh and to measure, to deal with time and space and mass and their related concepts, and to find more and more our knowledge expressed and our needs satisfied through the concept of number, as in the dreams and visions of Plato and Pythagoras; for modern chemistry would have gladdened the hearts of those great philosophic dreamers.

“But the zoologist or morphologist has been slow, where the physiologist has long been eager, to invoke the aid of the physical or mathematical sciences; and the reasons for this difference lie deep, and in part are rooted in old traditions. The zoologist has scarce begun to dream of defining, in mathematical language, even the simpler organic forms. When he finds a simple geometrical construction, for instance in the honeycomb, he would fain refer it to physical instinct or design rather than to the operation of physical forces; when he sees in snail, or nautilus, or tiny foraminiferal or radiolarian shell, a close approach to the perfect sphere or spiral, he is prone, of old habit, to believe that it is after all something more than a spiral or a sphere, and that in this ‘something more’ there lies what neither physics nor mathematics can explain. In short he is deeply reluctant to compare the living with the dead, or to explain by geometry or by dynamics the things which have their part in the mystery of life. Moreover he is little inclined to feel the need of such explanations or of such extension of his field of thought. He is not without some justification if he feels that in admiration of nature’s handiwork he has an horizon open before his eyes as wide as any man requires. He has the help of many fascinating theories within the bounds of his own science, which, though a little lacking in precision, serve the purpose of ordering his thoughts and of suggesting new objects of enquiry. His art of classification becomes a ceaseless and an endless search after the blood-relationships of things living, and the pedigrees of things dead and gone. The facts of embryology become for him, as Wolff, von Baer and Fritz Muller proclaimed, a record not only of the life-history of the individual but of the annals of its race. The facts of geographical distribution or even of the migration of birds lead on and on to speculations regarding lost continents, sunken islands, or bridges across ancient seas. Every nesting bird, every ant-hill or spider’s web displays its psychologic problems of instinct or intelligence. Above all, in things both great and small, the naturalist is rightfully impressed, and finally engrossed, by the peculiar beauty which is manifested in apparent fitness or ‘adaptation,’—the flower for the bee, the berry for the bird.

“But the physicist proclaims aloud that the physical phenomena which meet us by the way have their manifestations of form, not less beautiful, and scarce less varied, than those which move us to admiration among living

things. The waves of the sea, the little ripples on the shore, the sweeping curve of the sandy bay between its headlands, the outline of the hills, the shape of the clouds, all these are so many riddles of form, so many problems of morphology, and all of them the physieist can more or less easily read and adequately solve; solving them by reference to their antecedent phenomena, in the material system of mechanical forces to which they belong, and to which we interpret them as being due. They have also, doubtless their immanent teleological significance; but it is on another plane of thought from the physieist's that we contemplate their intrinsic harmony and perfection, and 'see that they are good.'

"Nor is it otherwise with the material forms of living things. Cell and tissue, shell and bone, leaf and flower, are so many portions of matter, and it is in obedience to the laws of physics that their particles have been moved, molded and conformed.

"How far, even then, mathematics will suffice to describe, and physics to explain, the fabric of the body no man can foresee. It may be that all the

Fig. 1.—The human skull is shown by Thompson with the superimposed Cartesian coordinates. (1, 2, 3, 4, and a, b, c, d.) By plotting a series of homologous points on the skull of a chimpanzee, and drawing a smooth curve through these points we have the deformed grid related to the chimpanzee's skull.

Fig. 2.—This grid is shown in Fig. 1, the curves being projections of the coordinates on the human skull. By this graphic method Thompson is able to show the prognathism and small brain of the chimpanzee as compared to man. Fig. 2 also contains skull of baboon, showing the deformed grid as related to this order and permitting a comparison with man and the chimpanzee.

laws of energy, and all the properties of matter, and all the chemistry of all the colloids are as powerless to explain the body as they are impotent to comprehend the soul. For my part, I think it is not so. Of how it is that the soul informs the body, physical science teaches me nothing; consciousness is not explained to my comprehension by all the nerve-paths and 'neurones' of the physiologist; nor do I ask of physics how goodness shines in one man's face and evil betrays itself in another. But of the construction and growth and working of the body, as of all that is of the earth earthy, physical science is, in my humble opinion, our only guide.

“Often and often it happens that our physical knowledge is inadequate to explain the mechanical working of the organism; the phenomena are superlatively complex, the procedure is involved and entangled, and the investigation has occupied but a few short lives of men. When physical science falls short of explaining the order which reigns throughout these manifold phenomena,—an order more characteristic in its totality than any of its phenomena in themselves,—men hasten to invoke a guiding principle, and entelechy; or call it what you will. But all the while, so far as I am aware, no physical law, and more than that of gravity itself, no not even among the puzzles of chem-

Fig. 3.—Thompson's *Growth and Form* shows the nautilus is formed on a true logarithmic spiral.

Fig. 4.—Jay Hambidge (*Dynamic Symmetry*) shows the Greeks and Egyptians were familiar with the geometrical forms of living things, especially the spiral and related figures as shown in Fig. 3.

Fig. 5.—The vase shown in Fig. 4 is analyzed in Fig. 5 and shows that the craftsman who designed this vase was not only familiar with geometry but also the geometry of living things.

ical ‘stereometry,’ or of physiologic ‘surface-action’ or ‘osmosis,’ is known to be transgressed by the bodily mechanism.

“The terms *Form* and *Growth*, which make up the title of this little book, are to be understood, as I need hardly say, in their relation to the science of organisms. We want to see how, in some cases at least, the forms of living things, and of the parts of living things, can be explained by physical considerations, and to realize that, in general, no organic forms exist save such as are in conformity with ordinary physical laws. And while

growth is a somewhat vague word for a complex matter, which may depend on various things, from simple imbibition of water to the complicated results of the chemistry of nutrition, it deserves to be studied in relation to form, whether it proceed by simple increase of size without obvious alteration of form, or whether it so proceed as to bring about a gradual change of form and the slow development of a more or less complicated structure.

“In the Newtonian language of elementary physics, force is recognized by its action in producing or in changing motion, or in preventing change of motion, or in maintaining rest. When we deal with matter in the concrete, force does not, strictly speaking, enter into the question, for force, unlike matter, has no independent objective existence. It is energy in its various forms, known or unknown, that acts upon matter. But when we abstract our thoughts from the material to its form, or from the thing moved to its motions, when we deal with the subjective conceptions of form, or movement, or the movements that change of form implies, then force is the appropriate term for our conception to the causes by which these forms and changes of form are brought about. When we use the term force, we use it, as the

Fig. 6.—Left hand figure to illustrate the octants made by the three reference planes. Point *P* is represented in an octant. Right hand shows the octant containing *P*.

physicist always does, for the sake of brevity, using a symbol for the magnitude and direction of an action in reference to the symbol or diagram of a material thing. It is a term as subjective and symbolic as form itself, and so is appropriately to be used in connection therewith.

“The form, then, of any portion of matter, whether it be living or dead, and the changes of form that are apparent in its movements and in its growth, may in all cases alike be described as due to the action of force. In short, the form of an object is a ‘diagram of forces,’ in this sense, at least, that from it we can judge of or deduce the forces that are acting or have acted upon it: in this strict and particular sense, it is a diagram,—in the case of a solid, of the forces that have been impressed upon it when its conformation was produced, together with those that enable it to retain its conformation; in the case of a liquid (or of a gas) of the forces that are for the moment acting on it to restrain or balance its own inherent mobility. In an organism, great or small, it is not merely the nature of the motions of the living substance that we must interpret in terms of force (according to

kinetics), but also the conformation of the organism itself, whose permanence or equilibrium is explained by the interaction or balance of forces, as described in statics.

“Morphology then is not only a study of material things and of the forms of material things, but has its dynamical aspect, under which we deal with the interpretation, in terms of force, of the operations of energy. And here it is well worth while to remark that, in dealing with the facts of embryology or the phenomena of inheritance, the common language of the books seems to deal too much with the material elements concerned, as the causes of development, of variation or of hereditary transmission. Matter as such produces nothing, changes nothing, does nothing; and however convenient it may afterwards be to abbreviate our nomenclature and our descriptions, we must most carefully realize in the onset that spermatozoon, the nucleus, the chromosomes or the germ-plasm can never act as matter alone, but only as seats of energy and as centres of force.”* (Figs. 1, 2, 3, 4, 5.)

Precise measurements of the normal human denture reveal the symmetrical arrangement of the teeth in three dimensions.

Precise measuring, connotes the intelligent use of precision instruments with results expressed in terms intelligible to any person conversant with dimensional space.

To study the form of a denture we naturally turn to that branch of mathematics which has for its province the study of the properties of space—geometry. I recall a few of the principles of projective geometry:

Space is filled with points, lines and planes† and these are the elements out of which our figures are to be formed.

A line is a straight line extending both ways to infinity.

A plane is a plane surface extending in all directions to infinity.

Three planes, which do not meet in a line, have *one single point* in common.

A point is determined by three planes which do not pass through a line.

A plane is determined:

By three points which do not lie in a line.

A line is determined by two points.

Descriptive Geometry is concerned with the methods of representing solids and other figures in three dimensions by means of drawings in one plane. Britannica, page 707, Vol. II.

Solid Analytical Geometry. Any point in space may be specified by three coordinates. We consider three fixed planes of reference. Three planes which are at right angles two and two. They divide all space into eight parts called octants. (Britannica, 717, Vol. II.) (Fig. 6.) Coordinate is defined as a member

*In the discussion that followed the reading of this paper it was felt that I had advocated the conclusions of Thompson and Hambidge. It would be presumption on my part to assume that I am competent to be a judge of their splendid work.

†The object of incorporating the extensive quotation from *Growth and Form* and the illustration from *Dynamic Symmetry* was to show that men of science believed in the *mathematical approach* of any problem dealing with form and motion even though the form and motion pertain to *living things*.—F. L. S.

†It is understood that there are other surfaces than planes. Planes being but one of the divisions of the surfaces that are found in space.

of a system of lines or angles by means of which, as elements of reference, position is determined in relation to certain fixed lines or planes.

Vector, a line conceived to have both a fixed length and a fixed direction in space but no fixed position: That quantity which determines the position of one point in space relative to another, conceived as the line from one to the other.

A.

B.

Figs. 7 A and B.—Illustrative of the principle of orthographic projection. All parts of the object are transferred to planes of projection by sight lines at right angles to those planes. This kind of projection reproduces to full scale all dimensions parallel to the projection plane.

Fig. 8.—Surveying apparatus.

For convenience in measuring the denture we will resort to projection. When points in space are projected in straight parallel lines to a plane it is called orthographic projection. (Fig. 7.)

By means of a suitable surveying instrument (Fig. 8) dentures may be orthographically projected in three dimensions.

With these definitions in mind we will proceed to define *the occlusal plane* and *three reference planes*. All normal deciduous dentures close nearly on a plane surface.

All normal permanent dentures, in front of the molar series, are nearly flat. With respect to some plane surface which will conventionally be regarded as horizontal, every maxillary tooth (not a molar) shall extend as far below this

Fig. 9.—Solid lines upper gingival margins. Dotted lines lower gingival margin. Vectors of upper teeth solid lines from centroid of teeth to centroid of denture at O. Vectors of lower teeth dotted line.

Fig. 10.

plane as the corresponding mandibular tooth extends above it. This plane will be referred to as the *occlusal plane*.

The *centroid* of a tooth may be conventionally defined as the geometrical centroid of the closed line known as the "gingival margin."* The point thus defined is generally neither the geometrical centroid of the tooth nor the physical center of mass. Its only significance is that it is a centrally situated point in the tooth conveniently determinate and marking fairly well the location of the tooth as a whole. (Fig. 9.)

The centroid of a denture may be defined as the geometrical centroid of

*If a tooth in normal occlusion were translated on its vertical axis and should perforate a medium which would register the greatest circumference of the crown the resulting opening would be the "gingival margin."

the centroids of all the teeth comprising the denture. In the case of a denture conforming to the criteria for normal configuration, the plane surface containing the centroid of the denture and lying parallel to the occlusal plane, will be called the *plane of horizontal projection* or the *XY-plane*. Generally the XY-plane will lie near the occlusal plane: these two planes will coincide if the centroid of the denture happens to lie in the occlusal plane. These

Fig. 11.—Normal occlusion of teeth. Secretum apertum. (Summa.)

planes will conventionally be regarded as horizontal; accordingly, all planes at right angles to them will be vertical.

Centroid of denture at *O* (Fig. 9) is found by measuring from two bases the average distance of the tooth centroids from each of these bases where the lines cross at *O* is the centroid of the denture.

Having obtained the centroid of the denture we now proceed to find the

axis of symmetry for our group of tooth centroids. (*A-B*, Fig. 9, is axis of symmetry.) (Fig. 10.)

Given a number of pairs of corresponding points, P_1Q_1 , P_2Q_2 , etc., which are nearly symmetrically disposed on opposite sides of an axis, to find the axis *OY* of least asymmetry, viz., that axis such, that if the plane containing

Fig. 12.—Secretum apertum. Uppers solid line, lowers broken line, centroids of teeth, centroids of denture at *O*, axis of symmetry, *A-B*.

Fig. 13.—Secretum apertum. Tooth centroids, centroid of denture at *O*, vectors upper solid line, vectors lower broken line, axis of symmetry, *A-B*.

Fig. 14.—Secretum apertum map of upper teeth (plus centroids) in solid lines. Map folded on axis of symmetry *A-B* and the left side traced over right in broken line.

Fig. 15.—Secretum apertum, lower teeth (plus centroids) in solid lines. Map folded on axis of symmetry *A-B* and the left side traced over right in broken line.

points and axis be folded on that axis, then the *P* points shall as nearly as possible fall upon the corresponding *Q* points; in mathematical terms, the sum of the squares of the resulting small distances P_1Q_1 , P_2Q_2 , etc., shall be the least possible.

It can be proved, that the axis must pass through the centroid of the

system. Let O be the centroid of all the P points and Q points. Through O draw a line OY' bisecting the angle $Q_1 OP_1$. Measure the angles ϕ , ϕ , etc., between the OY' and the vectors OP_1 , OP_2 , etc., and also the angles θ_1 , θ_2 , etc., between OY' and the vectors OQ_1 , OQ_2 etc. Measure also the lengths p_1 , p_2 , etc., of the P vectors, and the lengths of the Q vectors.

Form a table as illustrated below, and enter in it the measured values of θ , ϕ , q , p . Find the difference $\theta - \phi$, the products qp , and the products $qp(\theta - \phi)$. Take the sums in the columns of qp and $qp(\theta - \phi)$, and finally take half the quotient of the latter sum by the former sum. The result, expressed in angular measure, is the value of the angle by which the line OY' diverges from the axis of least asymmetry, OY . In case the angle be positive, lay it off from OY' toward OQ_1 ; if negative, lay off toward OP_1 .

The method given for computing the angle to be used in locating the axis is not rigorously correct, but is closely approximate when the symmetry is good.

	Q	P	QP	θ	ϕ	$\theta - \phi$	$QP(\theta - \phi)$	
	41.2	36.9	1520	52.7°	52.7°	0.0	0	
	23.1	24.3	556	84.5°	81.6°	+2.9°	+1610	
	30.0	28.6	858	156.8°	151.2°	+5.6°	+4810	
			2934				+6420	
$\Delta = +6420$								
2×2934								

$$\frac{\Delta}{2 \times 2934} = +1.1^\circ$$

$$\text{angle } \delta = \frac{E[qp(\theta - \phi)]}{2 E[qp]}$$

Fig. 16.—Grid for testing symmetry.

Fig. 17.—Wilk's Case.

Let there be passed through the centroid of the denture and axis of symmetry the *plane of maximum symmetry*, this plane will be called the YZ plane (sagittal plane). A vertical plane containing the centroid of the denture and intersecting the XY plane and YZ plane at right angles will be called the XZ plane.

Three reference planes for a denture in normal occlusion have been defined above. They are XY , YZ , and XZ , and they all intersect at the centroid of the denture, which will be taken as the origin of coordinates and designated O . Any orthographic map of the denture will be made by projecting at right angles to one of the three reference planes. If the projecting is done at right angles to the horizontal plane XY , the map will be a horizontal projection;

if at right angles to YZ a side elevation; if at right angles to XZ , a front or rear elevation.

The location of any tooth with respect to the reference planes may be given by the coordinates $X Y Z$ denoting the distances of the tooth centroid from the three planes, any single point may be defined in like manner.

In surveying a denture it is important to get the correct level of models in order to establish the plane of projection (XY plane). Let the model of the denture in malocclusion be mounted on a surveying instrument and leveled according to the judgment of the operator, the aim in levelling being to estimate the direction of the XY plane in relation to the model and make this plane parallel to the horizontal motions of the instruments.

Let the model thus mounted be surveyed in three dimensions. The horizontal projection or plane, will not be appreciably affected by faulty levelling unless the vertical malocclusion is extreme and the levelling greatly in error. (In order to avoid waste of time a side elevation can be made in "open or close bite" cases) and this can be tried over a standard side elevation

Fig. 18.—Wilk's Case.

Fig. 19.—Wilk's Case.

taken from a case of normal occlusion any error (in levelling and establishing the XY plane) can readily be detected and the correct level found. A more definite and precise method of levelling will be published shortly in a paper describing arch determination and map placements to produce a minimum of tooth movement.

Secretum apertum, probably the most famous skull in orthodontia will now be analyzed by means of orthographic projections, its symmetry tested by calculating the centroid of the denture and its axis of symmetry. (Fig. 1.) Secretum apertum* (Angle, malocclusion of the teeth, page 15, Fig. 5.)

By means of a transparent sheet ruled in 5 centimeter squares the symmetry of any occlusion or malocclusion may be tested by placing center line A. B. over the axis of symmetry.†

*The surveys of Secretum apertum were made by Dr. Juan Manes Retana, of Madrid, from models (of the skull) made by Dr. J. Lowe Young, who kindly loaned them to the writer.

†The symmetroscope of Gruenberg should be studied by the reader, also its modification by Sheldon Fried, both reported in *Dental Cosmos* of 1912 and 1914. Also the studies of Van Loon, *Dental Cosmos* of 1915 showing the craniophor. Dr. Morse also has used transparent celluloid ruled in squares. Morse measured the asymmetry by placing the celluloid sheet over the mandibular and the maxillary models. Morse axis was established by eye.

The following figures marked Wilks case were made from models of a patient who had nearly normal occlusion. No legends will be required as it has been treated in the same way as secretum apertum; the legends of which are to be applied to these figures (17 to 20, also Fig. 9).

The two cases show a remarkable degree of symmetry, and present normal occlusion in a new light—a symmetrical arrangement of the tooth centroids about a common centroid *O*. *Homologous tooth centroids having vectors of nearly equal length and angle.*

Fig. 20.—Wilk's Case.

Fig. 21.—Dewey case.

Fig. 22.—Dewey case.

We now propose to test the symmetry of some cases of malocclusion.

Dr. Martin Dewey, after examining our method of determining the axis of symmetry, proposed a test of the method and selected for his test one of the cases in his clinic. (Figs. 21, 22, 23, and 24.)

By placing the cross section paper over this map all asymmetries can be measured. *The line A.B. is the sense line of the denture* and should be of great help to orthodontists. (Figs. 25, 26, and 27.)

The next model to be tested is case No. 1436 of which Figs. 28, 29, 30 and 31 show four views of this case. On the right side the mandibular teeth

are completely inside the maxillary arch while on the left side shows a near approach to the norm.

Figs. 32 and 33 show the maps of the maxillary arch.

The last case I will show is one sent by Dr. Angle for diagnosis. Four

Fig. 23.—Dewey Case.

Fig. 24.—Dewey case.

Fig. 25.—Orthographic map of Dewey model shown in (Figs. 21, 22, 23, and 24.) Upper teeth solid lines; lower teeth broken lines, *A-B* axis of symmetry, *O* centroid of denture, squares 5 mm. to test the symmetry, centroids of the teeth marked with dots.

Fig. 26.—Upper jaw, Dewey model.

Fig. 27.—Lower jaw, Dewey model.

views of this model follow. (Note the lower right canine is impacted and its space is occupied by a supernumerary.)

Figs. 34 and 35 show the right and left side of the case.

Figs. 36 and 37 show the front and occlusal views. Figs. 38, 39 and 40 show maps of the above case.

Fig. 28.—Case 1436

Fig. 29.—Case 1436.

Fig. 30.—Case 1436.

Fig. 31.—Case 1436.

The model shown in Figs. 34 to 36 was submitted for classification to fourteen orthodontists with the following results: Eight classified the case as Class II, Division 2, subdivision (distoclusion), one as being Class II, Division 1, subdivision (distoclusion), and five placed it in Class I (neutroclusion).

The Angle classification is based "on the mesio-distal relations of the

teeth—dental arches and jaws which depend primarily upon the positions, mesio-distally, assumed by the first molars on their erupting and locking. Hence in diagnosing cases of malocclusion we must consider, first the mesio-distal relations of the jaws and dental arches as indicated by the relation of the lower first molars with the upper first molars—the keys to occlusion and second the positions of the individual teeth carefully noting their relations to the line of occlusion.” Angle defines the line of occlusion, “as being the line with which in form and position according to type, the teeth must be

Fig. 32.—Orthographic map of Case No. 1436. Uppers solid lines, lowers broken lines, centroids of teeth are dots, *A-B* axis of symmetry, *O* centroid of denture. Note relation of lower arch on right side.

Fig. 33.—Upper map of Case 1436. Axis of symmetry *A-B*.

Fig. 34.—Angle Case.

Fig. 35.—Angle Case.

in harmony if in normal occlusion.” He further states that “There can be but one true line of occlusion of each individual and the line of occlusion should be in harmony in form and position with and in proper relation to all other parts of the great structure” i.e., the body.

“We speak of moving a tooth of the lower arch into the line of occlusion or of moving the tooth of the upper arch into the line of occlusion, but it must always be remembered that there can be one *true line of occlusion*.” Angle. “This line describes more or less of a parabolic curve and varies with

the limits of the normal according to race, type and temperament. It is difficult to determine exactly what the form of this line should be in each given case."

Angle proceeds to define the positions of teeth in malocclusion in relation to the line of occlusion. "That we should have a line from which to note variations from the normal in the positions of teeth is important," he then proceeds to say there are seven positions of malocclusion:

1. Outside the line, buccal or labial.
2. Inside the line, lingual.
3. Further forward, mesial.
4. Opposite, distal.

Fig. 36.—Angle Case.

Fig. 37.—Angle Case.

5. Not sufficiently elevated in socket, infra.
6. Too great elevation, supra.
7. If turned on its axis (which axis not stated), torso occlusion.

Angle further states that "the upper first molar furnishes more nearly than other tooth or point in the anatomy an exact scientific basis from which to reason on malocclusion." This attempt to define the malpositions of teeth in reference to a line has led to some curious results. Such a keen observer as Angle states that the malposition of teeth consists principally in the variation of their crowns from the normal with usually little displacement of the apices of the roots. Orthographic projections of malocclusion show many teeth that are much out of position yet requiring translation—the root end moving an equal distance with the crown. Angle in describing an open bite, Class 1

case, with the molars and premolars in good (page 43) occlusion says, "Fig. 24 shows a case where there is infraocclusion of both maxillary and mandibular incisors with probably *slight supraocclusion of the molars.*" If the line of occlusion has a fixed position in the skull as Angle stated, and supraocclusion means erupting beyond the line of occlusion how can a maxillary and mandibular molar grow past a fixed line at the same time and yet occlude?

In Class II, Division 1, Angle states that the mandibular teeth are distal with *lengthened* and protruded maxillary incisors—orthographic projections find

Fig. 38.—Orthographic map of Angle model shown in Figs. 34, 35, 36, and 37. Uppers solid line, lowers broken line. *A-B* axis of symmetry.

Fig. 39.—Upper map of Angle model. *A-B* axis of symmetry and trace of *YZ* plane. Also note trace of the *XZ* plane through the centroid of denture at *O*. Note lack of symmetry at end of arch.

Fig. 40.—Angle model (lower). Axis of symmetry, *A-B*, centroid at *O*, trace of *XZ* plane through centroid *O*.

Fig. 41.—Arrows indicate mesial movements as applied to individual teeth and to the lower jaw.

these teeth shortened. Many other flagrant contradictions could be pointed out but it seems unnecessary. "Any plan which is fundamentally based on an error of principle is doomed to failure."

The writer proposes the abolishment of Angle, Case and Lischer Classifications, together with most of the present terminology of orthodontics. If you turn from one text to another you will find error piled on error. Case 1921 Edition of Dental Orthopedics in defining the occlusal plane says: "The front part of the lower plane curves upward." "Posteriorly the plane curves

slightly downward and then as it passes the first molars it again curves slightly upward." Planes curving! Oh, shades of Euclid!

A body in space can only be: 1. Rotated on an axis. 2. Bodily displaced. 3. Bodily displaced and rotated.

In translation all points in a body move in similar directions equally.

In rotation a body turns on an axis.

Why should we add such a suffix as "version" when we wish to express the position of a tooth in malocclusion?

An incisor bodily displaced toward the lip is said to be in labio-version. Now "version" implies a turning. "Thus if the vector function is the velocity of a fluid at the different points of space its curl or *version* is the rotation of that fluid." The suffix version seems a misnomer as it implies that all teeth in malocclusion are rotated upon some axis, *said axis not stated*.

Consider the term mesial, a mesial direction is defined as toward the median line along the curve of the arch.

In Fig. 41 the arrows on the teeth show the various directions of mesial when applied to the different teeth. When the jaw is moved mesially the teeth move with it; the arrows show the direction of movement when the jaw moves mesially. We now find the incisors moving at right angles to the movement we previously designated as mesial. If mesial means toward the median line of the skull, how can a mandible be moved toward the median line when it is on the median line?

Dr. Dewey has pointed out editorially the futility of using mesial and distal.

Dr. Hopewell Smith of Pennsylvania has criticized the orthodontic use of mesial and distal saying we have reversed the anatomical meaning of these words.

It seems futile to further point out the fallacies of our classifications and terminology. They have well served their purpose. I believe the Angle classification will always stand as a great achievement without which orthodontic progress would have been much delayed. Any work I have done has been inspired by my contact with Angle.

"When we sincerely find we cannot agree with the past we must break with it no matter how great the prestige of its messengers."

So it seems better to adopt a simple precise terminology.

The writer suggests the following: forward or backward, right or left, up or down, rotation.

Forward to mean toward the front of the head in lines parallel to axis of symmetry.

Backward: opposite to forward.

Right or left: direction at right angles to axis of symmetry.

Up and down: parallel motion (up and down) to the vertical plane through axis of symmetry.

Rotation, turning on an axis. Axis to be stated.

Classification is not needed in such a system. The Angle model presented

today should be sufficient argument against a classification upon which experts cannot agree, especially as treatment of living tissue is based on classification.

The method offered is governed by rigid mathematical formulae easily understood and applied, and has the further advantage of being the language commonly employed for similar purposes in all other fields of applied mathematics.

The adoption, more generally, of the mathematical approach for the study of malocclusion may reveal the true deforming forces at work on the human denture leading to the adoption of preventive measures that may supercede our costly and lengthy treatments with mechanical devices.

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