

Research Applicable To Orthodontia Prior To 1930

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The Program Committee assigned this topic with these words: "Research applicable to Orthodontia prior to 1930 — you should cover the contributions of Todd, Hellman, Oppenheim and Angle and include such other material as you choose." The joker of course lies in the "such other material."

In order that we may recognize what we are testing it seems logical to define research. Webster's New International Dictionary (2nd Ed.) puts it this way:

"A studious inquiry or examination; specifically, critical and exhaustive investigation or experimentation having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories, or laws, in the light of newly discovered facts, or the practical investigation of such new or revised conclusions —."

My own limitations have prevented my reviewing the foreign literature, particularly that in German and French, and personal choice has resulted in omitting the work of many orthodontic pioneers whose contributions should be noted. But these omissions should not be regarded as too serious for our purposes here; in many cases these men either walked in the shadow of Angle or their material was almost frankly partisan. For the former, Angle's own work is more than adequate; for the latter, their views need not concern us today. Still others, Downs has kindly consented to scan. There are also a few authors whose findings and deductions hewed to the line as they saw it, studiously avoiding the impediments and cross-currents of injured pride and shallow thinking.

When going swimming it has always been my choice to take the plunge at once, preceding this only with a slight testing via the pedal digits. Having here found the water of a temperature required by "*Salvelinus Fontinalis*", I propose none-the-less to dive in with a belly-smacker.

Some have long felt that orthodontic progress has been impeded by the previously mentioned cross-currents in our field and by the domination which Angle exercises to this day. Let it be recognized here that this domination was and is more of a weakness in ourselves than a fault of his. It is to be added that your essayist is no less guilty than any other of failing to see the forest for the trees. Further, it is primarily by virtue of hindsight, largely impelled by the almost twenty years of work flowing from the Bolton Study, that your speaker now recognizes errors in his own and some of the traditional Angle reasoning.

It is the purpose here to outline the contributions of the four men assigned and to contrast those of Todd and Hellman with those of Angle, then to touch on some of the work of Keith, Lewis, Rogers, Johnson and

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Hrdlicka and, in particular, that of Lundstrom. Correlation of these viewpoints is my theme.

It seems gratuitous to review Angle's work (1907) before this society. We are all familiar with his lifelong aim to establish adequate graduate and post-graduate orthodontic instruction, with his insistence on technical perfection and with his undersanding of facial balance and harmony.

As stated by Broadbent, Angle's primary genius rested in his ability to correlate. It was only through long and careful observation together with "rigorous thinking," that Angle developed his ideal of normal occlusion, his concepts of the maxillary first molar position, the "Line of Occlusion" and his classification. These Angle principles served to bring order out of chaos, to put technical methods on a simple basis, to rationalize treatment and to generate a tremendous enthusiasm among his followers. The latter of itself was one of Angle's greatest contributions, not always recognized and sometimes even harmful because it blinded us to the other side.

But throughout his writings runs the central theme that maloccluded teeth result in facial disharmony and that establishment of normal occlusion would change all to harmony and beauty by thereby restoring correct function. When "E" arch therapy disappointed him, he devised the working retainer from which evolved the Pin and Tube Appliance. The operative disadvantages of this led to the simpler Ribbon Arch and this was further simplified by the Edgewise Arch appliance. Most failures were attributed to the operator's mistakes, to lack of cooperation, to third molars, to endocrine imbalance, and to what-have-you but especially to lack of, or improper, function and never to developmental handicaps that may make the situation largely unsolvable by ordinary methods long before the orthodontist is consulted.

Perhaps as much as any other one thing, the classical work of Oppenheim (1911) was responsible for reinforcing Angle's theories. Oppenheim portrayed histologically the actual changes, as Angle had foreseen them, and showed too the blocked tooth movement, and even damage, resulting from too extensive force or force of an indefinite character. Thereafter, Angle always strived for more perfect force control and for intelligent case analysis and treatment planning to the end that tooth movements once initiated should be carried through without interruption.

However, Oppenheim's tissue changes were only those in immediate proximity to the teeth. It has been assumed that similar reconstruction occurred more remotely and this assumption was abetted by a liberal interpretation of Wolff's Law, together with the biologist's principle that form is dependent on function.

This law, formulated in Berlin in 1892 by Julius Wolff after thirty-one years of orthopedic practice, was given the title "The Law of Bone Transformation." The accepted translation is as follows:

"Every change in the form and the function of bone or of their function alone, is followed by certain definite changes in their internal architecture, and equally definite secondary alterations in their external conformation, in accordance with mathematical laws."

In framing his law, Keith (1919) has observed, Wolff buried a simple and vital truth in words. Keith also observes that "the late Dr. John B. Murphy of Chicago found a much simpler expression when he said: 'The

amount of growth in a bone depends upon the need for it.''' In further interpreting Wolff's law, Keith emphasizes the engineering role of the osteoblasts—"the architecture of the neck of the femur is being constantly remodelled, *but the osteoblasts maintain the same complex design throughout.*"

May we not reasonably say, barring pathological processes, a mandible is always a mandible? I have found but one reasonably adequate and authentic report dealing with complete anodontia but this gives empirical support to the theme that masticatory function is not an absolute requirement for jaw growth. The role of such function in jaw development is another matter. Keith's reasoning seems to point to Roux' differentiation between "two kinds of form-development, the purely hereditary non-functional or pre-functional and that evoked by a stimulus to function." Much evidence points to the hereditary factor as the more important in form-development. "An organ which in the course of development is influenced by its function does not, according to Roux' 'morphological law for functional adaptation' increase uniformly, but the increase takes place only in such dimensions as supply this increase." (Lundstrom—1925) This would indicate that reduced or improper muscular function only modifies bone in the area of attachment. Even the intensive masticatory function of the Eskimo has not resulted in wider dental arches than in other races with less function (*ibid.*). Further, it is permissible to ask whether the broad, prognathic Eskimo face is not more a racial character than a product of function (Hrdlicka). In short, normal tooth material and the stimulus of proper function are only part of the requirements for facial balance; defects of growth and development can so modify bone as to interdict ideal tooth position and facial harmony.

MILO HELLMAN

In 1908, there graduated from the Angle School one Milo Hellman. His first appearance in the literature was in 1915 in which he followed the path of his teaching. He was attempting to demonstrate the morphological changes induced by treatment and it was a scholarly effort. By presenting the theoretical, histologic and radiographic evidence then available plus an analysis of his own clinical results, he proved his point. But even then he had some misgivings; despite his reasoning along the lines of tradition already noted, he wrote the following: "maloccluded teeth themselves are but diagnostic landmarks—due to malformations in the jawbones" (1915).

It was shortly after this that he turned to comparative anatomy and anthropology in seeking answers to the questions he could not answer. He studied arch form in the primates and found that the orang's was not uniform in outline, and that the lack of incisor over-bite was not an exclusive character. Further, he attributed the diastema to developmental influences and to functional activity of the canine teeth (1918). This was followed by a similar analysis of man (1919). He found no relation between tooth size and arch form, declared that both anthropoids and man showed an extreme diversity of arch form, postulated that evolutionary processes influencing the number, form, position and occlusion of teeth are factors in arch form and theorized that racial characters might have a close relationship to it.

The then reigning interest in Class II deformities led him to an etiological analysis of such cases (1922). Though he was able to demonstrate

a sixty per cent correlation between thumb and finger sucking children and Class II malocclusions, he was careful to point out this was "a positive but not an exclusive relationship." He further concluded, "malocclusion of the teeth is essentially an expression of some discrepancy in growth; growth is modified by accelerations and retardations; when influenced by pathological conditions these accelerations and retardations result in deformities."

Almost fifteen years later it is easy to see why it was once said to me that Hellman has always had a "negative" viewpoint. Those conclusions were indeed earth shaking in that day and were simply not comprehended.

In order that this may not stray too far from Angle's principles it is well to return here to Hellman's second appearance in the literature (1917). This paper is perhaps the finest exposition of the Angle concept of normal occlusion embodied in the following: "the shapes of the cusps, crowns and roots, even the very structural material of the teeth and their attachments are all designed for the purpose of making occlusion the one grand object, in order that they may best serve the chief purpose for which they were intended, namely, the cutting and grinding of food."

To return to Hellman's intellectual development, he questioned the concept of normal occlusion (1920, 1920b, 1922). Again he used anthropology, paleontology and anatomical collections for his evidence. He said this concept was insufficiently supported by concrete evidence; collected material did not correspond to this ideal. He noted the retention of primitive features in man's teeth (that is, their size and form and the dominance of the mesiolingual cusp of the maxillary first permanent molar) and concluded that the "human type of dentition" was developed along evolutionary lines but not necessarily that of normal occlusion. This line of thought obviously led to the paper in which he stated categorically that normal occlusion is a myth (1921).

There was also a series of papers dealing with nutritional problems, perhaps the least fruitful of any of his work (1919, 1923, 1925).

Somewhat later he was challenging the improvement in facial expression following orthodontic treatment and attributing it to development (1927). Again, he questioned the constancy of position of the maxillary first permanent molars, a major error as we have recently seen.

Because of this interest in development he undertook a study of skeletal progress, as revealed radiographically in the epiphyses of the hand, on a small group of Hebrew orphan girls. This group was followed for only four years but he found that the age range of twelve and one-half years to fourteen years was "filled with significant physiologic processes."

Returning to his doubts as to what facial changes are produced by orthodontic treatment, Hellman now undertook his great study of facial development as analyzed in various collections of skulls (1927, 1927b, 1928). He classified the material on a physiologic time scale omitting differences of sex and chronologic age. In addition to defining the changes in facial height, width and depth and delineating their chronologic maxima, this work produced evidence of posterior growth at the maxillary tuberosities and at the posterior borders of the mandibular rami and of the swinging out of the face from beneath the cranium. It also refuted the old error that the gonial angle of the mandible started and ended with a straight line. Growth and development were clearly differentiated and in a later contribution, refining and condensing this accumulated evidence, he re-stated a principle half-sensed in an early paper, as follows: "In

disturbances of development of the face, the teeth can be used as symptomatic features of considerable diagnostic value" (1929).

Milo Hellman's work can not be left without citing his investigations on Simon's Orbital Plane (1930). Again he went to tremendous lengths in gathering data which, with Broadbent (1927), simply obliterated the basis of Simon's work (1926). This report can well be taken as a model, but our primary interest in it lies in his last two conclusions. He attributed Class II, Division I malocclusions "to insufficient and disproportionate development in certain regions of the jawbones. Adequate knowledge of development as it affects the human face is a prerequisite . . . for the orthodontist."

In the case of Hellman's research prior to 1930, we have traced the evolution of his reasoning from an initial acceptance of the purely functional concept of occlusion to the opposite concept that maloccluded teeth are only symptoms, in many cases, of deficient bone development. Hellman was among the first to question the functional etiology of malocclusion, to recognize the difference between bone growth and bone maturation and to investigate the complex problem of developmental growth of the face. It may be added he was also among the first to attempt the use of lateral roentgenographic images to portray facial changes and to assess skeletal maturation on the basis of epiphyseal changes.

T. WINGATE TODD

In reviewing the work of Todd prior to 1930, by and large one witnesses much the same intellectual development seen in Hellman. Todd's first published material appeared in 1911 and had to do with a surgical problem, for his training was primarily in that field. The following year we find a study on the growth and development of bone (1912). About this time he arrived in Cleveland and published a series of articles dealing with man's place in nature (1914). These studies culminated in the text, "An Introduction To The Mammalian Dentition."

Of interest from the above studies are his views as to the stability of man's dentition—the distinctively human dentition appeared in the Oligocene period, "a period so remote that we can barely conceive its distance from us now"—and as to the currently popular belief concerning allegedly retrograde changes in man's dentition as evidenced by small third molars. He states, ". . . there is great variation in the size and development of the third molar but it must be remembered that this tooth is normally small in the ancestors of modern stock and therefore increase in its size is much more noteworthy than reduction in size. The second molar is undergoing most obvious retrogression in the human race, especially in the Europeans. We see this clearly in its reduction in size and its loss of cusps. . . ."

Perhaps the most monumental of his published material was that dealing with suture closure (1924, 1925). Of interest here is the finding that sutural closing is most active at 25-30 and that final closure occurs only in one's declining years.

In the same year, in another paper we find the following in reference to the reliability of measurements based upon subcutaneous bony points, "when it can be separated from other observational errors, the instrumental, due to direct measurements of dimensions upon the human body, amounts to about five millimeters in a significant sample. . . ."

A paper in 1928 contains much of value and interest to orthodontia for it is primarily a setting forth of principles of developmental growth. Indeed, the title is "The Anatomy of Growth." Here he emphasized "the dissociation of growth" as being both an increase in dimension and a change in proportion. Regarding the interplay of growth and environment, he declared that dimension is a matter of heredity on the one hand and nurture on the other. He discussed the methods of measuring growth and showed that assessment of the developmental age is superior to other criteria because, (1) it is independent of both heredity and nurture, (2) it is qualitative and not quantitative, (3) the skeleton is most adaptable to this end and (4) bony development is independent of general bodily features (i.e., height or weight). Todd then goes on to the practical application of these principles—a child's maturity level is assessed in terms of his age, height, weight, roentgenographic development and muscular power. These criteria will demonstrate different types of undernourishment for "the undernourished child may be a human weed" with his height disproportionate to his other features. In short, not how old, or how tall, or how heavy, but how well do the various criteria blend in the over-all picture of a child as a soundly functioning individual?

The following statement of general principles are Todd's conclusions to this paper:

1. Growth has two phases.
2. Each may be influenced apart from the other.
3. Qualitative differentiation of limb epiphyses is the most practical method of showing time-linked standards of measurement.
4. Definite time-linked stages of development may be identified in the grade school child.
5. Boys are more closely time-linked than girls.
6. These criteria are independent of factors induced by heredity and nurture.
7. Analysis of undernourished children may be made by these methods.

In the same year Todd established the practical accuracy of measuring from lateral roentgenograms (1928).

Todd's last contribution presently of interest to us appeared in 1929. Here we find reinforcement for Angle's concept of the relatively constant position of the maxillary first molar for Todd cites the predominance and size of the first permanent molars and states that the human pattern has developed by emphasis of these teeth with maintenance of short jaws. His mention of the crowded lower incisors in the mandible found at Le Moustier, France, could echo Hellman's view of normal occlusion as being a myth. He outlines the general program of facial development, stressing the growth spurts of the jaws coincident with molar eruption, and traces the same in the deer and in baboons. Finally, he mentions the importance of the palate bone in vertical growth and pictures that bone as a "stanchion" against the antero-posterior growth of the maxilla.

Of equal interest in the same paper is the explanation of principles to be deduced from careful analysis of defective growth: defects may be localized or generalized; bone growth consists of two processes, (A) the addition of substance, which is growth and (B) the abstraction of substance which is maturation or modelling; cranial growth is not uniform but has gradients of time, place and degree; to permit this discontinuous growth to occur there must be considerable adjustment of parts. Therefore, we should examine closely areas where increase in dimension pre-

dominates and other sites where there is adjustment between adjacent areas exhibiting various degrees of growth. Here, also, he characterizes the long canine not as a carnivorous tooth but as required for long-jawed animals as a dental guide.

We have now traced, all too glibly, the development of Todd's interest from an initial histological study of bone and the evolution of the human dentition, through his efforts to learn more of bone qualitatively, to his realization that accurate appraisal of skeletal maturity represented a new and highly dependable method of assessing a child's relative health level. Here we leave Todd, on the very threshold of cephalometry.

It needs to be emphasized that from a reading of the literature of this period it would appear the advent of cephalometry was largely stimulated by the work of Todd and Hellman. The truth is probably the opposite; although the greater part of Broadbent's work appeared after 1930, there is little doubt his association with these men, especially with Todd, had a great impact in modifying their traditional thinking and methods.

OTHER AUTHORS

There remain to be cited some of the work of Johnson, Hrdlicka, Keith, Lewis, Lundstrom and Rogers.

Johnson's reasoning led him to revise the accepted conclusions of the time to the following: "Defective teeth can not be understood and treated by oral diagnosis and mechanical appliances alone. These organs may involve arrests of skeletal development affecting the oral cavity, arrested or perverted function of the muscular system, systemic disorders growing out of impaired vital functions or even arrested development of the brain" (1923). He also questioned the effect of Class II treatment on any tissue other than the alveolar process. This in 1923!

Hrdlicka drew upon his vast anthropological experience in formulating the following statements as conclusions to a paper on etiology: "Malocclusion is a disharmony in the normal relations of the teeth and as such is always secondary to other conditions. Malocclusions, as such, are, strictly speaking, not inherited, but conditions may be inherited which give rise to them. Racial mixing is of not great importance etiologically. Prognathism of the jaws is an ancestral and not an abnormal condition" (1922).

Published at about the same time was a paper entitled "A Contribution to the Mechanism of Growth of the Human Face," by Keith and Campion (1922). The burden of this was that the "adenoid" face was not due to a simple mechanical cause (i.e., mouthbreathing) but "an arrest or a disturbance of the elaborate machinery which underlies facial growth." They went on to conclude that the typical Angle Class II mouth-breather syndrome is "a manifestation of a single pathological state." They were unable to define that state but theorized that it might be of an endocrine nature or nutritional.

The clinical observations of Lewis and Lehman (1929) may be cited to emphasize the role of both function and growth. Among their conclusions are found the following: "Variation is the rule in occlusion of the deciduous series; occlusion is affected by growth changes and by factors influencing growth; in thumb-sucking cases, where the habit is broken before the fifth year, the malocclusion tends to correct itself." This latter, in the light of clinical experience, is confirmed only in those cases where there is not a developmental problem.

Axel F. Lundstrom's major work was published in Stockholm two years prior to its appearance in this country (1925). In it he undertook to analyze critically the theory that treatment is to be regarded as a mechanical and functional problem, from a "practical-orthodontic" point of view, and to provide evidence that "in a considerable number of cases the teeth are to be considered as secondary factors." His views were founded on his clinical data from six hundred and fifty treated cases; of these he selected one hundred and sixty-five based on their time out of retention and hence to be regarded as permanent results. His treatment was based on Angle theory and appliances and his observations were supplemented by a vast amount of reading; his bibliography may be cited as all-inclusive of the then available material. Today his paper may be ranked alongside Angle's contributions as the most penetrating analysis of orthodontic problems.

Briefly, after stating the problem, Lundstrom traces the evolution of the functional theory and examines the evidence supporting it. He then discusses his own theories and classifies malocclusions etiologically on the basis of (A) "Local-dental" causes (his term is "momenta") and (B) those "caused by abnormal conditions in the apical base." The bulk of the latter are created through inadequate development of the apical base manifested laterally and antero-posteriorly. He is undecided as to the proper grouping for inadequacies in the vertical plane. He then makes a severe analysis of the data he has used to support his claims; most of this portion is used to refute the "supposed effect of function" on the dental arch's development to normal form. His argument and his evidence from phylogenetic evolution, from research work and from various papers is sometimes tortuous but none-the-less convincing.

In this connection various essays of Rogers (but one is cited here) present interesting clinical evidence of the effects of function. Though one may question the degree of permanence of some of his Class II treatment, on the whole his pioneering in the re-education of muscles gives proof of the occasional potency of reduced and improper function. Two factors seem to have worked here in addition: first, careful case analysis in ferreting out causative factors; secondly, occlusal interferences positioning the mandible. In the latter cases Thompson has recently demonstrated this more clearly but Rogers also recognized the program (1924).

Among others, Lundstrom reviews the animal experimentation of Baker (teeth were removed or their vertical dimensions reduced by grinding to remove the function of part of the denture) and declares the resultant abnormalities were produced by "extensive loss of tissue." This seems to be quibbling; however, we can at least assume that he results were influenced to some degree by an absence of normal function.

In other words, function is a factor in facial and dental development but only within limits; it is not all-pervading and where a developmental problem exists, function will not maintain orthodontically corrected tooth positions. We need not sacrifice our enthusiasm for Angle principles; we must temper it and them to the realities of developmental growth of the face. Recognizing that function can and does modify tooth position, "when the apical base is normal, and only then, is a normal position and a normal occlusion of the teeth possible."

Lundstrom concludes with the statement that with recognition of the problem as he defines it, "... the object of treatment will be the attainment of an occlusion (in harmony with the given or potential apical base)

possessing a functional and hygienic optimum. . . . it is clear that in a considerable number of cases this optimum cannot be normal occlusion. The most urgent duty of mechanical orthodontics, therefore, is to endeavor to determine how in every given case such an optimum is to be attained." How prophetic of Tweed and Downs!

It is plain that the views of Hellman and Todd are paralleled by Lundstrom's. The Angle concept performed an inestimable service but pure loyalty is no substitute for "rigorous thinking" based on careful observation.

CONCLUSIONS

1. Evaluation of the relative etiologic roles of function and developmental growth in any given case is the primary problem of clinical orthodontics.
2. Interception of inhibitory developmental growth factors is our primary hope in preventive orthodontics and calls for the closest relations with pediatrics.
3. Serial cephalometric appraisal is a requirement for such evaluation and interception.

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