The Anatomic and Physiologic Factors Influencing Denture Arch Form and a Discussion of the Part Played by Each*

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Any discussion of this subject must necessarily be in the nature of a review of the writings of past and present leaders in the science of orthodontia. There is no thought of attempting to present new material for it is manifestly impossible to improve on Dr. Angle's original observations though a few men have been able, through their associations with him, to more clearly interpret those observations. This is rather an attempt to fix clearly in the writer's mind some of the basic principles of orthodontia.

Clinical observation has established quite accurately the anatomic factors which contribute to the form of the dental arches. The same can not be said for the physiological factors for it is but recently that any but the slightest recognition has been accorded these latter. The reasons for this rather anomalous state of our knowledge are well known and are not germane to the topic; suffice it to say that the tardy recognition of these factors can not diminish their importance.

In the seventh edition of his text Dr. Angle has summarized the anatomic factors as follows, "Normal occlusion of the teeth is maintained, first, by harmony in the sizes and relations of the dental arches through the interdependence and mutual support of the occlusal inclined planes of the teeth; and second, by the influence of the muscles labially, buccally, and lingually."[1]

This statement has been broken into its component parts by Dr. Strang who thus enumerates the factors maintaining normal occlusion of the teeth;[2] (1) the force emanating from the functional contact of the inclined planes of the teeth; (2) the musculature of the organ of mastication; (3) normal tissue metabolism; (4) normal tooth contact; (5) normal axial position; (6) stability resulting from the arrangement of the teeth in harmonious arch forms, and (7) rigidity of the two bases upon which the dental arches are built.

* Membership Thesis, Mid-Western Component Group, Edward H. Angle Society of Orthodontia.

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For the sake of convenience in this discussion "normal tissue metabolism" and "rigidity of the bony bases" will be discussed on another page and to the above factors has been added "normal tooth anatomy."

These, then, are the anatomic factors which influence dental arch form. To indicate the part played by each is more difficult because they do not operate as individual factors but rather as "interdependent" forces. One can not say that proper arch form is primarily dependent on the functional contact of the occlusal inclined planes because this force would be as nothing in the absence of the others. To achieve clarity, however, it will be advantageous to discuss each separately.

"The inclined planes of the cusps of the teeth already in normal position play an important part by directing the teeth that are erupting to take their normal positions in the arch, but if their influence be perverted they may become mischievous factors in the production of malocclusion."[3] Thus these planes may be said to play a highly important role in evolving dental arch form for when they lock abnormally there is usually evolved the typical disfigurement noted in a Class II or Class III deformity.

Secondly, the inclined planes serve to maintain the normal arch form and to impart functional stresses to the underlying bone. This has been perfectly expressed in the following words—"The blows received upon the occlusal surfaces of the teeth when the masticatory muscles contract radiate throughout the basal bones in definite lines of force distribution and the cellular elements in the tissues of support lay down fibrous and bony elements in just the correct amounts and at the most strategic locations to properly withstand all dangers and tendencies of displacement."[4] And again, "The greatest developmental factor in the case of the jaws, next to the inherent growth force, is the shock of the occlusion of the teeth."[5]

The third anatomic factor which we noted above was that of normal tooth contact. When there is a deviation from the correct proximal contact between any two or more teeth, some of the stability which maintains arch form is immediately lost and there is a greater or less change in that form; the degree of the change depending upon the components generated by the forces of occlusion and the relative normality of the physiological factors. Such changes usually affect the antero-posterior proportions of the arches, for the segments of teeth on either side of the slipping or lost contact, tend to tip toward and occupy the space thus created.

The importance of normal axial position is either underestimated or not comprehended by many in the profession. Normally, the axial positions of the teeth approximate the vertical, though there are of course deviations

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from this. It is this axial relationship which dictates the laying down of osseous tissues "at the most strategic locations to properly withstand all dangers and tendencies of displacement." The force generated by the functional contact of the inclined planes and distributed to the basal bones through the axial lines of, as an example, the lower teeth in Class II—Div. 1 cases, is thus directed posteriorly and therefore modifies the inherent growth forces as well as stimulating osseous depositions best calculated to form a base for this backward pounding. The end result is a malformed mandible and lower arch. Similarly, the lower jaw and arch in Class III, demonstrate the malformation that results from just the opposite inclined plane relationship and axial inclination.

Each year it is becoming more clear that the musculature of the organ of mastication plays an important rôle in developing and maintaining arch form. There are various perversions of muscle functions in which a functional act may be performed incorrectly, or be repeated endlessly though in the proper manner, with resultant modification of normal arch form. Incorrect swallowing habits are examples of the former while sucking habits exemplify the latter. I am unaware of any source where the entire problem of muscle habits is as intelligently and clearly discussed as in the "Textbook of Orthodontia." The interplay of these muscular forces is intricate and has no place here, but the broad principle of the effect on the arches can not be better expressed than in the following quotations.

"If these (the muscles associated with the oral cavity) are balanced and harmonious in their interplay, the effect upon the structures to which they are attached and upon the tissues that they press when contracting, is beneficial and stimulating, aiding in the production of normal form, position and contour. If, on the other hand, there is a perversion in this muscular activity with disharmony in the force delivered upon the various structures, there is bound to be abnormality in the form and growth of the tissues so effected."[6]

"While we think of these muscular forces as destroyers of tooth alignment, after it has been established, yet we must also remember that, if active during the period of tooth eruption, they do not actually break down arch form but rather prevent the molding of the denture into its normal size and shape."[7]

Finally we have to consider normal tooth anatomy. Only when the tooth is formed according to its present evolutionary and hereditary standard will it properly deliver and receive functional forces. The pattern of man's teeth is such that there is not only a specific point for proximal contact on

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every tooth but, more important, the occlusal surfaces are so designed that a three-fold thrust is delivered by the mechanically conceived inclined planes of each cusp on the buccal teeth. This means of equilibrating the masticatory stresses of inclined plane function is beautifully described on pages 27 and 28 of Dr. Strang's "Textbook of Orthodontia." He concludes as follows: "Consequently in ordinary mastication, the pressure on the teeth in all directions is maintained at an equilibrium though the movement of the mandible may be confined more to one type of joint action than to another."

This brief discussion of the anatomical factors brings us to a consideration of the component arising from the forces of inclined plane and proximal contact. When two antagonizing teeth contact each other through their inclined planes the energy of the masticatory muscle contraction is at once translated, by these planes and through the long axis of each tooth, to the basal bones as a definite force. If the inclined planes were arranged other than they are or if the movement of the mandible were in a true vertical plane, the force thus created would soon destroy the underlying tissues and doubtless the teeth as well.

We have just seen how the inclined planes are so planned, mechanically, as to dissipate this force in three directions—i.e., "either mesial and distal and also buccal or lingual, or buccal and lingual and also mesial or distal." On analyzing the up and down excursion of the mandible it is found that it moves in the arc of a circle the convexity of which is directed anteriorly. Because of this the teeth, in normal occlusion, adopt an axial inclination which is best suited mechanically to receive and deliver this thrust. Such an inclination is of course a slight mesial one. We can now see that masticatory force is further dissipated in an anterior direction—when two forces meet at an angle the resultant is the component of the forces.

At this point we begin to understand the importance of these anatomical factors. If it were not for the support, through proximal contact, of each tooth to its neighbor, this anterior force would be a harmful one as indeed it is when the various factors we have been discussing are not balanced. Even the support of proximal contact would fail to adequately resist this anterior force but with the stability derived from harmonious arch form and the antagonism of the muscle groups all the forces are balanced, one against the other, to produce the perfect whole.

When the arch forms are inharmonious, for one reason or another, then the resistance to this anterior force is lessened, the inclined planes do not mesh correctly, etc., etc., with the result that all the forces become un-

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balanced, the teeth are shifted until the stresses are again balanced and each tooth is positioned to be in harmony with mechanical requirements.

It was Dr. Angle, of course, who first called attention to this force component which he so aptly termed the "Anterior component force." And it was he who so beautifully expressed all the foregoing in the sentence, "The sizes, forms, interdigitating surfaces, and positions of the teeth in the arches are such as to give one another, singly and collectively, the greatest possible support in all directions."[8]

Thus, as pointed out previously, it is erroneous to consider these various forces individually except for purposes of discussion. They are completely "interdependent" and only when each force is perfectly balanced with and against each other force and is in harmony with the physiological factors, do we see normal occlusion in all its beauty and majesty.

The physiological factors are those which have to do with hereditary influences, perversions of muscle tonicity, constitutional diseases, faulty diet and endocrine disbalance.

The part played by heritable factors in our field has been the subject of much discussion in the past, and a great part of it has been empirical, having no regard for existing scientific evidence and theory.

Dr. Angle first directed attention to the fact that at the time of conception there is a definite provision made for the denture and all its parts; that the denture develops in accordance with this plan.[9] If, by some mischance, there is a failure to properly provide for the entire denture, a greater or less degree of malocclusion eventually develops. It seems reasonable to thus account for missing and supernumerary teeth. The former act on the arch form by creating spaces which the teeth on either side tend to occupy; such a space destroys the integrity of the arch form and thus reduces its stability. Supernumerary teeth may produce malocclusions by usurping space meant for other units thus reducing the available arch space. Frequently they so far disturb the eruption of a normal permanent tooth as to modify its position, delay its eruption and complicate treatment.[10]

It is thought that the factor of inheritance may also play a part by producing an inefficient bodily mechanism. Such a patient is often found to be the offspring of unusually robust and vigorous parents but he himself will be developmentally retarded and seemingly subject to such excessive inherent growth forces as to produce a child of marked incoordination whose growth occurs quite exuberantly and in sharply defined periods. In these cases, the "increase in bodily dimensions" is markedly inharmonious with the coincidental "changes in body proportions," (growth, as de-

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fined by Todd) and this growth factor, together with a marked nervous instability, produces a greater or less malformation of the arch form.

Clinical evidence is constantly being accumulated to demonstrate the evil effects of hypotoned muscle groups which not only fail to furnish proper support to the arches but in some cases may actually produce the opposite result by virtue of their very bulk. In a similar manner hypertoned groups act on the existing arch form to contract it, usually in localized areas.

Just where the orthodontist can place the blame for perverted muscle tonus is not clear at the present time. We do know it is most frequently observed in those children whose growth periods are unusually irregular. It seems more reasonable to believe that it may be caused by a trophic endocrine or dietary factor rather than inheritance.

Perhaps the most typical example of a hypotoned muscle group is that in the lower lip of Class II Div. 1 cases. Here the bulk of the lip is such that it presses against the lower anterior segment, resisting the normal anterior growth force and thus aiding in the production of an excessive curve of Spee, as well as resting beneath the crowns of the upper incisors and thereby facilitating their labial axial perversions.

The characteristic effects of hypertonicity are well pictured in many Class I cases. Here we see the buccal musculature in an abnormally tense state together with the same condition in the lips, where it is especially evident in the canini and triangulares muscles; the components of these abnormal forces determine the malocclusion. There usually results a crumbling of the arch form, a forward drift of the buccal teeth, overlapping and rotating of the anterior teeth, or a supra-occlusion of the anteriors; in fact all, or any possible combination of these malpositions may eventuate. In most cases the problem is further complicated by the presence of a swallowing habit.

Constitutional diseases and nutritional faults may be conveniently discussed together. Any factor which affects the individual's general bodily resistance and well-being is bound to be reflected to some degree in the dental arches, secondarily to the mal-effects produced in the quality of the osseous tissues.

It will be noted that the lowering of the mechanical efficiency of bone is spoken of as the primary result of constitutional and nutritional upsets. This is emphasized because these upsets often create highly susceptible bony conditions by a process of "demineralization," under which any unbalanced forces may the more readily move the teeth and modify the denture arch

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form as the dental units attempt to harmonize their positions with the mechanical demands of these forces.

There are two aspects of the problem of nutrition. On the one hand demineralization of bone may be accomplished by a faulty diet—one lacking in proper vitamins, or mineral elements; on the other, the demineralization may be due to faulty assimilation of food materials. In the latter case a diet apparently quite adequate in all respects fails to gain the usual bone stability; somewhere in the chain of the body's physiology there is a missing link which prevents the individual properly using the food at hand. Whether this fault may be laid at the door of inheritance, or endocrine activity, or just where, our present knowledge can not tell us but it is another problem which must be solved before complete orthodontic service may be realized.

The entire problem of the demineralization of bone, its causes, effects, diagnosis and treatment was recently discussed by Dr. T. Wingate Todd before the Eastern Association of Graduates of the Angle School of Orthodontia in New York City in an illustrated talk, "The Physical Makeup in the Child."

The factor of the endocrines remains for consideration. For the present it is known that the ductless glands exercise a potent influence on all growth and development and, therefore, on dental arch form. The mechanism of this influence is not as yet clear. It is certain that the existing knowledge is insufficient to permit the orthodontist to prescribe treatment in this field.[11] We can only hope that the various research workers will soon supply us with this invaluable and indispensable information.

To conclude, a review of this nature only serves to impress one once more with the complicated nature of the many factors which influence the development of normal occlusion and with the complete interdependence of these various factors. Only when they are all balanced and harmonious can the Plan of Occlusion be realized.

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