The Temporomandibular Joint and the Occlusal Curve as Factors in Determining Tooth Position*

DAVID W. MCLEAN, D.D.S.

Los Angeles, California

The entrance of oral physiology into orthodontics is a direct result of the great change in dental thinking that has come during the past quarter of a century. Slowly at first, but with gathering momentum as new knowledge continuously opened up new vistas, we have come to realize that the dentist—and therefore also the orthodontist—is treating not the teeth but the patient. That statement considered superficially, seems almost trite. But when we stop to analyze and apply it our objective and procedures change completely. We could do many things to teeth; we could save many teeth; we could overlook many shortcomings in teeth—if we did not have to consider the ultimate effect upon the patient's general health. Once we concede that dental activities influence the patient's health—not spectacularly as a rule, but persistently and inexorably through the years to come—we are compelled to assay our every procedure from the viewpoint of its long range possibilities for good and evil.

No profession has ever before been called upon to make the staggering advance dentistry has made in the short time that has elapsed since the coming of this modern concept. Orthodontics has progressed marvelously in this direction. Every precaution is used to avoid inducing caries and peridental disease as a direct result of treatment. The health influence of an increased dimension of the nasal passages, with resulting better areation and sinus drainage, has been realized; the interrelation between malocclusions (and their treatment) and the endocrine balance has not been overlooked; the psychic and therefore actual physical effect of improved personal appearance has been realized to the full. The next advance required of both orthodontics and general dentistry is a greater attention to the establishing or enhancing of oral physiology.

Anatomy and Physiology

Anatomy exists only as the foundation for physiology in the oral as well as in other fields. This is of special moment to the orthodontist, since

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he is remaking anatomy. When oral function is perfect nature has brought certain definite anatomic factors into coordinated relationship. Where some inherited or extraneous influence interferes to prevent such a coordination the individual has a malocclusion and calls upon the orthodontist for help. The orthodontist steps in to remove the interference so far as may be possible, to rearrange oral anatomy and to bring about that harmony of the anatomic factors of function which nature failed to achieve.

Remembering always that nature's prime objective is function, what could be more logical than for orthodontists, who are in a sense nature's pinch-hitters, to adopt the same prime objective and to recognize and use the anatomic factors which accomplish it? After all, the most beautiful individual—the most beautiful feature—is the one orientated and formed for perfect function. Place the dentures in ideal functional relationships with each other and with the individual's skull and you have not only the most perfect oral function but also the most perfect esthetics.

Anatomic Factors of Oral Physiology

The anatomic factors which form the basis of oral function fall naturally under three headings: (1) the temporomandibular joints, (2) tooth form and (3) tooth position in the jaws, which consists of arch form and the occlusal curves. Some of these anatomic factors may be changed by treatment; they are the pliable factors. Those not amenable to direct and reasonably prompt change we term nonpliable factors.

The temporomandibular joints should always be considered a nonpliable factor of oral function. It is true that patients with malocclusion often acquire the habit of chewing in abnormal jaw and joint relationships and that resulting morphological changes will eventually take place in the temporomandibular joints. These changes are dependent upon resorption and calcification of the densest type of cortical bone; they take years to occur. Meanwhile the teeth, during countless nonmasticatory closures each day, are subjected to perverted axial and lateral stresses due to the application of force against the inclined planes of their cusps. In due course the peridentium will break down, with pathology, infection, loss of teeth and perhaps focal infectious disease as an end result.

The second factor of oral function, tooth form, has in the past been considered a nonpliable factor in orthodontic treatment. The modern health concept places upon us such great exactions in developing masticatory function that it becomes not only proper but necessary for the orthodontist to modify tooth form to the extent of removing cuspal antagonisms by selective spot grinding, bearing in mind always that the grinding must not subject

the tooth to unwarranted menace of caries. Within this restriction it is entirely in order, when orthodontic treatment has done its utmost, to mark areas of cuspal interference and remove the interference.

Cuspal interference does two important things: it subjects the antagonistic teeth to terrific peridental strain and it renders all other teeth inoperative in that jaw position, greatly limiting masticatory function.

Selective grinding to enhance cuspal cooperation during masticatory jaw movements should have a place in all orthodontic curricula, as it is a science and should not be undertaken without full understanding. To mark the cusps of teeth with articulating paper and whack off all of the marks with a large stone is to ruin the occlusion. Each carbon mark must be analyzed and the appropriate part of it selected for grinding. When selective grinding will not bring about the desired cooperation of one or two individual teeth after orthodontic retention is complete, it is in order to refer the patient to a competent general practitioner to have the occlusal surfaces of such teeth reformed with veneers of hard metal to coordinate them for occlusal function.

The third factor of oral function, tooth position in the jaws, is the freely pliable factor of orthodontic treatment. It is through manipulation of this pliable factor—through tooth movement—that the orthodontist accomplishes in malformed dentures during childhood what the general practitioner accomplishes in middle life by occlusal reconstruction of worn out and mutilated dentures, and what the prosthodontist accomplishes in later life by means of artificial teeth. First, function; second, esthetics.

The Temporomandibular Joints

Early anatomists classed the temporomandibular articulation as a ginglymo-arthrodial joint—as a gliding hinge. That is just what it is. If you will think of a hinge which can glide sideways or downward and forward; which can pivot on one end and glide downward and forward on the other, at the same time gliding bodily sideways and functioning as a hinge, you have a clear cut picture of these points in action.

In simple hinge opening of the jaw and in simple protrusion it is easy to visualize the two condyle heads moving in unison. In lateral jaw movements one condyle head pivots and moves slightly sideways while the other moves in a complex arc. Nevertheless, the condyle heads are still moving in unity; they are still suspended upon an imaginary hinge axis around which they can and do perform simultaneous hinge movements while gliding and pivoting on the temporal bones.

Between the mandibular fossa of the temporal bone and the mandibular condyle head lies an interarticular disk of fibrocartilage. This disk divides the joint into two parts: the upper portion which does the gliding and the lower portion which performs hinge movements. One synovial membrane covers the floor of the mandibular fossa and reflects back upon the upper surface of the cartilage disk, permitting the disk and condyle head to glide as a unit upon the temporal bone. A second synovial membrane covers the concave lower surface of the cartilage disk and reflects back over the convex condyle head, permitting the head to rotate in the disk on a hinge axis located somewhere in the condyle head. All of these movements can take place simultaneously.

This means that one or both condyle can move part way down the inclined floors of the mandibular fossae and there stop to perform the hinge and gliding movements used in the chewing function. Many patients with malocclusion do this, unconsciously finding the place where their misplaced teeth chew most effectively. Such an abnormal chewing position we have termed a convenience relationship or convenience bite. In these cases, which are very common in orthodontics, the temporomandibular joints are functioning upon the inclined surfaces of the mandibular fossae; muscles and ligaments are under constant strain, and arthritis of the temporomandibular joints, with clicking and often pain during chewing movements, will eventually result.

During diagnostic examination the patient with a convenience bite will close repeatedly in the abnormal position, so that one would naturally think it the normal relationship and arrive at a wrong diagnosis. The first essential in diagnosing a malocclusion, therefore, is to make sure that the condyle heads are back in their normal rest positions, in the bowls of the mandibular fossae. The patient is instructed to open the mouth wide, to relax and close. As he does this, the doctor places thumb and forefinger on the tip of the chin and exerts gentle retrusive pressure. The condyle heads will be felt to drop back to the bottoms of the mandibular fossae and come to rest there. By pure hinge action the jaw will close in true centric relationship. It may be that only one or two teeth will occlude in this position and it is readily seen why the patient does his chewing elsewhere.

If this method of obtaining true centric relationship between the dentures is ineffective there is a second method. The patient is instructed to swing the jaw open and shut about a quarter of an inch repeatedly. At the same time a gentle retrusive pressure is exerted on the tip of the chin; the patient is instructed to relax—just to let the jaw swing loosely. One can feel the musculature relax and the condyle heads glide back and stop in the bowls

of the mandibular fossae. The guiding pressure on the chin should be gentle, for two reasons. If the pressure is too heavy the patient will resist it in self-defense so that it will be impossible to get the necessary muscular relaxation. Secondly true centric relationship is not the most retruded condylar position obtainable but rather the most retruded condylar position from which excursive functional movements can be freely and comfortably made.

When correct condylar position is thus made the basis of orthodontic diagnosis, it will be found that some cases which would have been placed in Class III really belong in Class I and others thought to be in Class I should properly be diagnosed as Class II. The intercuspation of the teeth, even when there are facets of wear present, cannot be accepted as an indication that the models are in true centric relationship to each other. When only one or two teeth contact in true centric closure it becomes necessary to make a bite registration in wax and mount the models upon an articulator which will hold them in proper relationship when the wax is removed.

The convenience bite relationship has another important bearing upon orthodontic practice. When a patient wears intermaxillary elastics he should be instructed to resist the elastics forcibly and keep his jaw back where it belongs. Many cases which appear to have relapsed into retrusion after discontinuance of retention have not really relapsed, but merely were never fully corrected. Influenced by the intermaxillary force, the mandibular condyle heads moved forward in their fossae and the patient acquired a temporary convenience bite in which the denture and cusp relationships were correct. Upon removal of the intermaxillary force the condyles gradually reassumed their correct position, drawing the lower jaw and denture back into retrusion.

Opening and Closing the Bite

Another interesting thing about the temporomandibular joints is that all changes in the level or degree of biting closure takes place in the lower half of the joint, upon the mandibular hinge axis. The axis is above and behind the body of the mandible and the denture; therefore opening and closure of the bite takes place on an arc from this center. In other words, closing the bite brings the mandibular denture not only upward but also forward; opening of the bite moves the mandibular denture downward and backward. This fact has an important bearing on clinical practice. A patient whose teeth have worn short closes the jaw abnormally far—in a Class III relationship. George Washington at the age of fifty-one had a normal Class I case; at sixty-one, after losing his natural teeth and acquiring the crude substitutes of that day, he became definitely a Class III case

despite the fact that his lips were probably stuffed out with cotton as he posed for his portrait. The patient whose bite has closed through wear and drifting of the teeth perhaps in addition to what was once a slight malposition, also becomes a pronounced Class III case. When treated by modern procedures, such as rebuilding the occlusion or providing artificial dentures, the biting level may be reopened and facial deformity corrected.

The significance of this fact in orthodontic treatment is readily seen. Extruding the teeth tends to correct Class III and to emphasize Class II denture relationships. Conversely, intruding the teeth tends to correct Class II and emphasize Class III relationships.

At the same time there are two counter considerations we must not overlook. First, extrusions should be brought about slowly and have their bony support developed to the new positions, lest the teeth be subjected to excessive leverage in shortened sockets. In adult life the peridentium would suffer retrograde and pathologic changes, accompanied by infection.

Secondly, opening and closing the bite not only changes the relationships of lower teeth to upper teeth but also changes the angle of axial stress. This fact may be demonstrated by a simple experiment. Upon a large black cardboard place a white cardboard mandible to operate upon a hinge axis pin placed somewhere in its condyle head. Fasten a rectangular piece of cardboard on the black card to represent the maxillary denture, and upon it draw vertical lines to represent the long axis of teeth. Place a similar denture card upon the mandible to represent mandibular teeth. Now rule vertical guide lines at the edges of the denture cards. To close the bite move the upper denture upward and the lower denture downward upon the ruled guide lines, just as though the teeth were being intruded. Then swing the mandible upon its hinge axis until the denture cards contact. There will be hyperclusion in the anterior part of the denture and changes in the angle of axial stress of all of the teeth. This means that when teeth are extruded or intruded the arch wire should be adjusted to upright the roots in the direction required to establish proper axial stress delivery upon the teeth.

Another important bearing of the hinge axis of the temporomandibular joint comes into play when models are mounted upon the articulator for diagnosis and treatment planning. If the bite is opened or closed upon an articulator when the models are in wrong relationship to the hinge axis of the instrument, the prosthodontist finds that artificial dentures will be subject to mesial or distal displacement or regional hyperocclusion when placed in the mouth, type and direction of denture malrelationship depending upon the direction and amount of error in hinge axis relationship.

Consider then, the case of a young patient whose teeth occlude well in a convenience relationship. In true centric his only contact is upon an upper lateral incisor which is in extreme linguoversion. All of the other teeth are held open; the bite is opened six millimeters by the interfering lateral incisor. The patient cannot approximate his dentures in the true centric relationship, nor can the models be held in correct centric relationship for diagnosis, except by mounting them upon an adjustable articulator. When the models are mounted, the interfering lateral incisor is removed and the dentures brought into centric closure for diagnosis, the bite will be closed six millimeters. If this closure takes place upon a wrong hinge axis the dentures will be in wrong relationship and the diagnosis will be erroneous. It is necessary, then, that models of such cases be mounted for diagnostic study and treatment planning and it is necessary also that they be mounted in correct relationship to the hinge axis if any change is to be made in the level of biting closure.

The Occlusal Curve

Tooth position in the jaw resolves itself primarily into two interrelated considerations: arch form and the occlusal curves. Without proper occlusal curves the most perfect arch form will fail to produce masticatory function. Without an arch form suited to the individual's typal characteristics we cannot have ideal function no matter how ideal the occlusal curves. Given correct individual arch form and the occlusal curves, an individual tooth may be rotated, uprighted or torqued to change the position of its cusps slightly and to produce functional contacts in the various jaw positions.

Our tendency in dental practice has always been to work to averages. We study a thousand skulls and arrive at an ideal—in other words, an average—arch form and occlusal curve. Then we give the patient these ideal forms and expect him to have ideally functioning dentures. Very well. Let us take the shoe size of every person in this audience, add them up and divide by the number of persons present. We now have the average or "ideal" shoe size for this audience. Do you think we could all wear shoes of that size?

The patient is always an individual. Nature has made him a complete, coordinated mechanism unlike any other individual in the world. Predeterminations of arch form should be made to produce harmony with the individual's functional and esthetic set-up. The same rule holds with reference to the occlusal curves.

Some years ago dentistry was given the so-called spherical theory of occlusion. The average—and ideal—occlusal curve was said to be a part

of an eight-inch sphere. Articulators were designed to operate on that bases, artificial dentures were made to chew around an eight-inch spherical curvature and the temporomandibular joints were expected to accommodate themselves to the movement. This is just as logical as the average shoe size, but the fallacy is still widely believed. If blocks of vulcanite or modelling compound are made to fit over a patient's natural dentures and shaped so they will maintain functional contact in every chewing movement of the jaw, the concave surface of the lower bite block should, if this theory is correct, conform to the surface of an eight-inch sphere. But when such a sphere is held against such a lower bite block we prove again that the patient is always an individual. His occlusal curves must be in harmony with the other anatomic factors of his own individual mechanism. As a matter of fact the patient has three occlusal curves unrelated to any common center. There is the longitudinal or mesiodistal curve of Spee and a lateral curve for each side of the denture.

When the mandible moves from centric relationship to protrusive, several anatomic factors play a part. The condyle heads move downward and forward upon the floors of the mandibular fossae in the temporal bones; this factor is known as the *condylar inclination.* At the same time the cusps of the lower posterior teeth glide down the inclined planes of the upper teeth; this is *cuspal inclination.* Simultaneously, the lower incisors and cuspids move diagonally downward across the overbite and forward across the overjet; this factor might be termed the *incisal inclination.* At the same time, due to tooth arrangement, the lower denture as a whole glides across the pitch and curvature of the upper denture; this might be called the *occlusal inclination.* When all of these inclinations coincide we have a perfectly coordinated protrusive movement.

Suppose that the condylar inclination is steeper or less steep than these other inclinations which are wrapped up in tooth anatomy and position: we would have antagonism between the dentures and their peridentium would suffer. So nature has provided a means for compensation, in the hinge axis movement of the condyle heads. The jaw can close or open slightly upon its hinge axis during the gliding movement to produce harmony between the discordant inclinations. The same picture of coordination obtains in the more complex lateral movements of the jaw.

Nature has, however, no way of compensating for maladjustments *within the occlusal curve itself.* If incisors are unduly long and receive full jaw pressure in the protrusive position there is no remedy except the orthodontist's. If the lateral curve of one side of the denture is too steep or too flat the only cure is by tooth movement. The orthodontist must recognize

such a short-coming and correct it if oral function is to be complete and future peridental pathology is to be avoided.

The decision whether to intrude anterior teeth or extrude posterior teeth to produce a longitudinal occlusal curve harmonious to the patient's other factors must depend upon two things: the esthetic requirements, determined by the length of the incisors with reference to the patient's low lip line (at rest) and high lip line (when smiling) and the functional requirements, represented by the positions of the bicuspids and molars and determined by an occlusal curve survey of the mounted models after the technique of Frank Wadsworth.

For this survey of occlusal curvature the articulator should carry above it a semaphore to receive the center for the occlusal arc. With dividers the three apices of the base of an equilateral pyramid are established by placing one apex at each condyle head and the third equidistantly located in the incisal region. From each of these points arcs are inscribed upon the semaphore and the intersections of the arcs will be the center for an ideal individual occlusal curve passing through the incisors and the temporomandibular hinge axis.

As a matter of clinical fact, such an ideal occlusal curve is seldom seen. Most curves have their centers somewhere in the horizontal semaphore arc, and even this occlusal curve becomes merely the base from which upper and lower teeth are slightly moved reciprocally to bring about the patient's *functional* occlusal curve in harmony with his other anatomic factors of joint movement and cusp height and angulation.

We determine then by means of lip lines the extent to which anterior teeth should be intruded or extruded. Experience must tell us the extent to which such movements can be carried. We then survey the occlusal curve to harmonize the posterior teeth to the new incisal relationship.

Practical Applications

Now you ask, how is the orthodontist to apply all this?

First he will thoroughly acquaint himself with these factors of oral anatomy and their coordination to produce oral physiology. He will learn how a deviation in one factor may be compensated for by changing the others. Above all, every orthodontist should be able to set up artificial teeth upon an adjustable articulator to produce coordinated occlusion. In the graduate course in orthodontics at the University of Southern California we have the students cut the teeth free one by one, upon the mounted models of actual malocclusion cases, and move them to functional positions. But whatever way the training is accomplished, the orthodontist should know, when he sees

a given cusp failing of contact with its cooperator in the opposite jaw in any functional jaw position, just what movement of uprighting or torquing of one or both cooperative teeth will be needed to bring that cusp into functional contact.

When invited to examine completed orthodontic cases, the author first examines tooth alignment and the static interdigitation of cusps in centric closure. He then instructs the patient to move the jaw slowly to the right or left. The patient's bewilderment usually proves at once that it has not been routing procedure to examine the denture relationships in functional jaw positions during the orthodontic treatment and that the orthodontist has studied only the esthetic tooth alignment and centric inerdigitation of the case.

We must realize that we may have beautiful static interdigitation of cusps and yet have no functional masticatory efficiency. Some tooth or cusp may force the dentures to ride out of occlusion the moment the jaw moves out of centric relationship. In chewing, the jaw closes at the right for the right hand chewing stroke or at the left for the left hand stroke. The teeth on that side first contact with their buccal surfaces continuous (edge to edge). The jaw carries the mandibular teeth across through the centric relationship to the opposite termination of occlusal contacts where the teeth of the opposite side are edge to edge. The jaw is then opened and returned for another stroke. During this shearing stroke the cusps of the mandibular teeth glide through the grooves and across the cusp ridges of upper teeth, each cooperating pair of cusps functioning as a pair of shears. If one or two cusps interfere with this coordination, mastication is interfered with and the antagonistic teeth suffer in due course from peridental disease and infection.

Having mastered, then, the principles of this paramount oral function and the anatomic factors which cooperate to produce it, and having learned to apply the principles in setting up artificial teeth, the modern orthodontist, each time the patient presents for treatment, observes closely the cuspal relationships in the various functional positions of the jaw and adjusts his appliances to upright, torque or slightly rotate the teeth or shift them laterally or mesiodistally to bring the cusps into the desired dynamic interplay. Such anomalies of tooth form and dimension and such cuspal antagonisms as he cannot overcome by most careful orthodontic treatment may permissably be corrected by judicious (and slight) selective grinding.

Let us in all branches of dental science always place function first and esthetics second, not that we love esthetics less but that we love function even more.

3780 Wilshire Boulevard.