The Physiology of Mandibular Displacement

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A treatment philosophy which is based entirely upon a single rational step-by-step procedure for any and all patients is sought after and happily assimilated by many practitioners. Such one-track-treatment thought trains have often been observed highballing their way through many chapters in the short history of orthodontics.

The ideal occlusion and the perfect profile are twin-shimmering grails eagerly sought after by patient, parent, and practitioner. We are fortunate that these two goals are compatible with and complementary to each other in the vast majority of our cases. Their successful attainment and preservation are the result of sound diagnosis and treatment therapy. These same goals, in some few of our cases, are unattainable with a purely mechanical approach. These cases are those wherein we find a reluctance on the part of biology to yield to the dictums of physics — whether it be given in units of orthodontic force or degrees of incisor angulation. The practitioner who follows a singular mechanical approach will, in a certain few of his patients, find a wide chasm separating his case from the desired successful completion.

One segment of this subject of difficult cases which is worthy of consideration contains those cases wherein there may exist significant differences in the maxillary-mandibular relation when examined statically on the one hand and dynamically on the other. Practically speaking, they have been referred to as mandibular displacements. It is the intended purpose of this presentation to describe the physiology of mandibular displacement and attempt to focus attention upon the role of displacement in orthodontic diagnosis, treatment and retention.

The basis of a dynamic analysis of our dental problems is found in muscle physiology, i.e., muscle tonus. The fact that muscle tissue, in vivo, has an active range and a resting length has provided us with a potentially important diagnostic approach.

Sicher and Tandler[1], in 1928, spoke of the rest position of the articulation, the "middle position", and described the role of muscle tonus in producing this position. Niswonger[2] focused attention upon the true vertical dimension of the face and related it to the involuntary rest position of the mandible.

Brodie[3], in his cephalometric study of human cranial growth, noted that the jaws of infants did not occlude prior to the eruption of their teeth and stated: "The evidence points strongly toward a constancy of position of the mandible, which position is maintained by muscle tensions."

Thompson[4] has illustrated the constancy of the rest position. His original hypothesis of stability has been altered to acknowledge the effect of disease, but the basic philosophy of rest position remains sound even under direct electrical studies[5,6] of the muscles themselves and oriented radiographic studies of the temporomandibular articulation.[7,8]

Blume[9], in 1947, studied the path of mandibular closure in Class II, Div. 1 malocclusions. He concluded that the

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majority of cases exhibited an upward and forward movement of the mandible to full occlusion. This movement was primarily a rotation as seen at the condyles. A small group of his subjects displayed an upward and backward path of closure from the assessed rest position to occlusion. He found, in these cases, that the condyle was retruded deeper into the articular fossa by a translatory movement.

Boman[10] studied normal occlusion subjects in which eighty-eight per cent of his sample exhibited an upward and forward path of closure from rest to occlusion. Twelve per cent of his group did show an upward and backward movement of the mandibular incisors in moving from rest to occlusion.

Ricketts[11] utilized direct laminagraphic radiographs of the temporomandibular articulation and determined that two-thirds of his sample of Class II, Div. 1 cases before treatment exhibited a downward and forward movement of the condyle from occlusion to rest, i.e., upward and backward path from rest to occlusion.

Ballard[12] has discussed the reflex mechanism producing abnormal paths of closure. Grewcock and Ballard[13] together have illustrated the clinical significance of abnormal paths of closure.

Ricketts[14], in 1955, had shown changes with cephalometric laminagraphy which would cast doubt upon the constancy of the rest position, or perhaps the manner in which it was obtained, in showing pre and post-treatment records of condyle-fossa relation. He proposes a hyperactivity in the protrusive muscles in Class II. Div. 1 cases due to speech, respiratory and masticatory requirements. He feels that this hyperactivity falsely positions the mandibular condyle down and forward in the fossa.

Knowles[15] describes the role of retained deciduous teeth in the production of mandibular displacement.

Thompson[16] has pointed out various directional movements that occur with mandibular displacements.

Fundamentally speaking, to accept the tenet that mandibular displacements exist one must demonstrate: (1) the movement of the mandible from rest to occlusion is along a path other than the accepted normal; (2) the abnormal path of closure is due to tooth interferences; (3) that the abnormal path of closure can be altered and corrected by altering tooth position and finally (4) that an abnormal path of closure can be produced by incorrect tooth movement. The accepted path of closure for the mandible from rest to occlusion in normal occlusion is generally upward and forward. This is based upon the studies of Blume[9], Boman[10], Glowacz[17], Thompson[18], King[19], Posselt[20], and Posselt and Brian[21]. In the anteroposterior direction, the normal bilaterally functioning musculature would bring about a direct mid-sagittal vertical closure without lateral shift.

The deviation of the mandible from a position of rest to full occlusion may be a lateral deflection to the left or right. These cases are generally seen in the deciduous or transitional dentition stages and show evidence of maxillary arch constriction. These patients in closing from rest to occlusion will move directly to the maximal occlusal position without initial tooth contact. Slow volitional closure will result in a tooth contact prior to maximal occlusion which prompts the shift.

Anterior mandibular displacements are often witnessed in the "pseudo" Class III case or in instances of anterior crossbite. The position of certain incisor teeth prompts an anterior shift of the mandible to permit maximal occlusion. Here again the mandibular movement from rest to full occlusion is altered to an excessive upward and

forward path with translation forward and downward of the condyles within the fossae. The presence of a tooth or teeth within the freeway space area initiates a protrusion of the mandible to provide full buccal occlusion. A lateral or posterior shift is impossible because of arch size incoordination and limited fossa area posterior to the condyle; therefore, an anterior shift is the only possible direction to attain maximal occlusal contact.

To the great majority of us lateral and anterior displacements are quite evident. In the lateral displacements, we observe the midline shift from open mouth to full occlusion, the constricted maxillary arch, the over-erupted, lingually placed, deciduous cuspids and the complete buccal occlusion of one mandibular segment. The anterior displacements reveal upright maxillary incisors with attrition of the labial incisal edges, and a marked change from straight profile at rest to concave profile with full occlusion.

Diagnosis in Posterior Displacement Cases

To many practitioners of dentistry, the diagnosis, description and degree of posterior displacement is still a controversial issue. The probability of a full Class II, Div. 1 malocclusion shifting to an ideal Class I occlusion with the orthodontic removal of prematurities is quite remote, but possible. It is rather more common to observe cases displaying lesser degrees of displacement.

Posterior displacement diagnosis and assessment is quite difficult. There are not too many absolute diagnostic features clearly defined. In the instance of anterior or lateral displacements, our prime criterion is tooth-to-tooth relation and their readily apparent shifts from rest to occlusion. The anatomic relations in the anterior of the mouth are quite visible and pronounced as displacement features. The differentiation, however, in Class II, Div. 1 posterior displacement cases is primarily in the assessment of a mandibular rest position, and clinically, the view cannot be from the direct lateral aspect. Prior to the advent of electromyographic technics, the operator had to content himself with obtaining a rest posture of the mandible by various means of phonation, swallowing, or relaxation while studying projected photos selected to relax the individual as well as many other methods intended to produce a minimal of muscular activity in the elevator muscles of the mandible. The reproducibility of the mandibular rest position was often limited by the investigator's approach and ability.

Shpuntoff & Shpuntoff[22] have discussed an electromyographic method of rest position determination. Javois[5] and Mullin[6] have shown that slight electrical activity may occur in the postural muscles of the mandible while it is at rest, but that a reproducible rest position could be obtained by utilizing electromyographic and cephalometric technics. Jarabak[23] points to some electrical activity with rest. Perry[24] et al. have shown the effect of psychic stimulation on the alteration of resting activity in the muscles of the mandible.

To eliminate a lengthy discourse on rest determination, it will suit our purpose at this point to state that speech, phonation and empty swallowing movements seemed best suited electromyographically for producing mandibular movement prior to assessment of a rest position. With confidence and deliberation, a careful operator can obtain a reproducible rest position; it will serve him as a potent diagnostic adjunct in determining the presence or absence of mandibular displacements.

A mandible which moves from the repeatedly assessed rest position to an

occlusal position superior and posterior should well create a suspicion of displacement in the observer's mind. There are also other diagnostic signs which seem to create and/or accompany posterior displacement cases.

One tooth sign that seems to be of importance is the mesiolingually rotated, maxillary first bicuspids. These teeth are often in complete buccal version to the mandibular arch and, in occlusion, seem to hold the mandible distally.

We have already mentioned Knowles' observation on over-retained maxillary deciduous molars. These teeth may be forced into the interocclusal space by the eruption of the second maxillary bicuspids. Their distal marginal ridges contact and wedge against the mesial marginal ridge of the mandibular first permanent molar. This action results in a reflex retraction of the mandible.

Excessive curves of Spee with supraerupted mandibular second molars will produce the same type of retrusion.

At the time of a functional analysis, an excessive bulging of the temporal as it contracts is sometimes indicative of posterior posturing of the mandible. If this is seen, oft times the placing of the operator's little fingers in the patient's ear will result in a definite compression and actual contact between the distally moving condyle and the examiner's little finger.

Many times prior to any orthodontic therapy, our young malocclusion patients will have definite and audible crepitus. This is indicative of abnormal joint function.

Treatment therapy in extraction cases can, and will, often produce displacements. With inadequate anchorage, the molars will tip into the mesial extraction sites. This places tooth material in the freeway space and will result in an attempt by the musculature to spare the teeth and ligaments of the joints from excessive trauma. There will be a posterior shift which will no doubt cause the operator to throw more Class II therapy into the case to overcome the accentuated Class II appearance.

Neurophysiology

Just what then is the true physiology (or pathology) of mandibular displacement? As orthodontists, we concern ourselves primarily with bone, teeth, and their intermediate link — the periodontal ligament. We are headed in the right direction, but we have not pursued the matter to its source.

The mandible moves about the temporomandibular joints by means of muscular contraction which is initiated, graded and restricted by neural impulses arising centrally or peripherally. Those arising centrally are conducted from the large Betz cells located among the top six cell layers of the cerebral cortex. The cells of Betz which are concerned with mandibular movement are restricted to a small area at the lateral of the cerebral cortex on the anterior aspect of the fissure of Rolando. These cells are the primary site for initiation of all voluntary activity. They are the same types of cells that produce shoulder, arm, finger movements; or tongue, lip, and eyelid movements. Those for mandibular movements vary from those for other volitional activity only in the cerebral cortex location and their associational and reflex connections. The cells of Betz and their associated upper motor tracts are not of too much concern to us in the study of mandibular displacement for, as mentioned previously, they are concerned with willed activity.

Our chief concern for the neural background of mandibular displacement is with the reflex level activity. A reflex is an involuntarily produced activity resulting from the stimulation

of a receptor organ, the conduction of an impulse from the receptor organ to an effector organ and the effector organ's response.

The primary components of the reflex arc of a displacement are the receptor organs of the periodontal membrane, the temporomandibular joints and the muscles themselves. The conducting systems are the maxillary and mandibular nerves, their brain stem synapse stations, their connections with the lower levels of the cerebral cortex and/or cerebellum. The effector organs are the muscles attached to the mandible.

Pfaffmann[25] and Stewart[26] have illustrated the presence of certain endings in the periodontal ligament which are sensitive to light pressure. Corbin and Harrison[27], as well as Szentgothai[28], have demonstrated the pathways which the impulses travel from the periodontal ligaments and muscles to the brain stem. These nerve endings (receptors) in the periodontal membrane are classified as proprioceptive. Proprioceptive receptor organs with similar pathways and functions are also found in the muscles of mastication as well as the temporomandibular joints.

Proprioceptive endings are primarily concerned with muscle and joint sense. They are chiefly encapsulated sensory endings and in the basic modality of proprioception are concerned only with connections to and from the subcortical levels. However, in association and integration with other sensations centrally, they may provide information to the cortices for higher synthesis.

Lateral Displacement

The typical lateral displacement is primarily a functional malocclusion. If the unequal and unilaterally synchronous muscle pattern is perpetuated without orthodontic correction, it is conceivable that the functional malocclusion may produce a structural malocclusion as well.

The neuromuscular activity responsible for a unilateral mandibular shift is bilateral in nature. Previous electromyographic investigations have corroborated the anatomists' contention that the temporal muscle is primarily a postural or positioning muscle. In mandibular displacement, the temporal muscles again show their positioning function.

The movement of the mandible through the freeway space is usually conducted by a bilaterally equal and synergistic contraction of the mandibular elevators. In the empty swallowing movements, in the mastication of a soft bolus and in certain speech movements the primary action is that of the temporals. In forced swallowing and mastication of a moderate or a heavy bolus, the masseters and internal pterygoids may enter in.

If tooth material is interposed within the vertical of the freeway space in such a manner as to prevent maximal occlusal contact, the mandible will be shifted by the musculature to a position of maximal contact which may vary from its median occlusal position. This movement to a displaced or eccentric position is the result of neuromuscular accommodation.

The basis for this eccentric movement is as follows: As the mandible moves from its rest position along a symmetrical path of closure produced by a balanced and coordinated musculature, a tooth prematurity is struck. The contact pressure of mandibular tooth against maxillary tooth stimulates the periodontal endings about the teeth which contact. An impulse is initiated which is propagated along the maxillary and mandibular sensory nerve roots to the mesencephalic level of the brain stem. A pattern of neuromuscular contraction is dominant which, with ease and efficiency, is best accommodated for maximal occlusal contact.

If the displacement is the result of a unilateral impingement of the freeway space, the musculature will contract with greater amplitude on one side to shift the mandibular teeth away from the prematurity to an occlusion that is more efficient. This could conceivably result in an anterior, lateral or posterior unilateral displacement. The greater majority are lateral with some degree of posterior displacement on the side of the prematurity and some anterior displacement on the side contralateral to the prematurity.

When we observe an anterior midline interference, we may have an anterior or a posterior displacement. An anterior displacement is usually associated with relatively upright maxillary incisors and an acceptable maxillary occlusal plane curve. In these instances the midline nature of the premature contact initiates a bilateral masseter and temporal contraction (probably also internal and external pterygoid contraction) which protrudes the mandible anteriorly to a position of efficient maximal contact.

If the maxillary incisors have an extreme lingual inclination and the level of the incisor occlusal plane is at a different vertical than the maxillary buccal segment, a distal displacement may result. These are the Class II, Div. 2 cases. In these instances the posturing effect of the temporal muscles retracts the mandible from the premature contacts and provides a maximal occlusion distally.

The distal displacement is difficult to assess in diagnosis and, to the neophyte, often is not fully recognized as a displacement until treatment is undertaken or completed.

The temporomandibular joints have a degree of freedom which is important in masticatory function. This degree of movement is often utilized through necessity to accommodate tooth contact positions. The teeth with their proprioceptive system have the capacity to affect jaw posture during occlusion. The posture of the jaw is controlled to a certain degree by the joint and muscle proprioceptors, but these are primarily active in nonoccluding jaw positions. If, in closure from a position of nonocclusion to occlusion, certain stimuli arise which signal improper balance or incorrect posture of the mandible, the musculature will search for a position of occlusion that will bring the greatest harmony and protection to the teeth, their supporting structures and the joints. In time, such a pattern of neuromuscular activity may well establish a habit (learned) position within the neuromuscular circuit which will circumvent the initial contact and will provide for a direct closure to the maximal occlusal position.

The normal and usual path of closure from rest to occlusion is an interextreme position (Posselt)[20] and is the result of a monosynaptic reflex (Szentgothai).[28] This closure pattern is present before the eruption of the teeth and develops with sucking and swallowing. The advent of the teeth and their eruption provides a possible reinforcement of this reflex or will necessitate an alteration of it. In those cases of reinforcement, the occlusal position is upon the arc of the innate monosynaptic jaw reflex. If the two do not coincide, then occlusal posture is altered to provide the maximum of efficiency and the minimum of trauma. In these cases the alteration of the usual jaw closure path is through unequal muscle response about the individual joints to provide a maximal occlusal position. The innate pattern is still present, but it is overruled by homostatic adjustment.

A very simple description of the physiology of the rest position and the physiology of a normal closure should assist us in our understanding of mandibular displacement problems.

The resting posture of the mandible is maintained by the tonic contraction of certain special fibers within the muscle bulk of the elevators of the mandible. These fibers are called intrafusal fibers in contradistinction to the regular muscle fibers which are extrafusal fibers. The intrafusal fibers are part of a very special sense organ found in voluntary muscle. These organs for stretch response were discovered over one hundred years ago by Hassal.[29] Ruffini[29] described them by stating: "Apart from the organs of special sense (ear, eye, etc.,) the body possesses no terminal organ that can compare with these in richness of nerve fibers and nerve endings."

Sherrington studied these special endings over a period of forty years and ultimately developed his theories of muscle reflex from the activity and responses of the muscle spindles.

The muscle spindles are found parallel to the regular muscle fibers. The intrafusal muscle spindles have a rather complex sensory system which receives signals regarding the state of tension within the muscle. The muscle spindles also possess a motor innervation which produces contraction of their intrafusal fibers upon proper stimulation.

With a parallelism existing between the regular muscle fibers and the muscle spindle fibers, shortening of the regular muscle fibers takes tension off the intrafusal fibers and they relax. If the muscle is stretched, these special sense organs are also stretched and they reflexly contract to prevent further straining of the muscle or to grade the speed and response of the extrafusal fibers' stretch. We have in the muscle spindle a very precise tension recording organ; not only will the sensory component of the spindle record tension, but also, if the tension in the muscle due to stretch increases too rapidly or to too great an extent, the muscle spindle will contract in an attempt to alter the new posture of the muscle and return it to its resting length.

A second and very important sensory organ associated with voluntary muscle is the Golgi tendon organ. This sensory ending is found in the tendon of muscle and it is in series to the muscle fibers. Therefore, with any change in length, either shortening or lengthening, these sensory organs signal the change to the central nervous system which then grades the contraction or stretch of the muscle through reciprocal innervation or co-contraction.

The most important function of both of these systems, one in parallel to the muscle fibers and the other in series to them, is to immediately signal any change in muscle length and attempt to return the muscle to its genetically ordained and functionally determined rest position.

Thus the healthy rest position of the mandible provides us with a physiologically ideal starting position or reference point for ascertaining the complexities of our orthodontic cases from the functional view point.

Empty swallowing movements of the mandible differ from masticatory movements in many ways — the principle one being the equality and synergy of the empty movements in contradistinction to the bilateral muscle contraction but unilateral dominance of the masticatory act. In many of our displacement cases the patient unconsciously selects his food to maintain a diet of soft, easily triturated boli. This is a direct result of the loss of power from the masseter-internal pterygoid complex in mastication and may be brought out in questioning the parent. These muscles do not display their true contractile power, but are reflexly inhibited by prematurities in the freeway space. The difficulty of mastication is directly proportional to

the severity of the displacement. The temporal muscles dominate in the dual function of closure and posturing the mandible to the most efficient maximal contact occlusion.

A posterior displacement of the mandible is initiated by proprioceptive impulses from premature tooth contact early in the eruption of the offending teeth. The impulse is transmitted to the mesencephalic nucleus of the brain stem and from thence to the motor nucleus of the trigeminal nerve. The signal from this point is centrifugal and is carried in the efferent nerves to the muscles of the mandible to affect a change in functional posture to a position of accommodation and efficiency. The adaptability of the neuromuscular system and the temporomandibular joints is greater than that of individual teeth in prematurity. The origin of the displacing reflex may occur at any period of occlusal development.

Its genesis is slow, but as unyielding as the eruption of the teeth. In time, a path of closure which circumvents the initial contact is developed through the muscle and joint proprioceptive systems.

The temporal muscles do a greater portion of the work of mandibular movement than the masseters particularly in swallowing, mastication and other acts which necessitate tooth contact or occlusion. The nonoccluding empty movements of the mandible do not call forth the necessity of the displacement and a more harmonious and balanced synergy of muscle activity results. The mandible moves in and about its rest position freely and, if the patient is requested to slowly and volitionally close, the prematurity producing the displacement is often struck.

Posselt,[20] Sicher,[30] and Donovan[7] have shown that the mandible of ideal occlusion individuals can often be retruded up to 1 mm from the position of maximal tooth contact. This range of movement is not found in all patients, but Lammie[31] et al. have speculated as to the possible basis for its existence. They feel that maximal power in masticatory strokes comes only when the mandible is distal to this maximal occlusal position. The closure into centric occlusion from this terminal position calls forth the support of the external pterygoid, internal pterygoid, masseter and temporal. This is a position of a power stroke and not a static condyle fossa relation.

It is possible that this slight space distal to the condyle is utilized in the repositioning of the mandible in the posterior displacement cases. It is certain that power in Class II, Div. 1 malocclusion, when biting in centric, is lacking and even more so in mandibular displacement patients.

The response of posterior displacement cases to treatment is quite variable. In certain instances the mandible will be repositioned forward by the musculature as soon as the reflex initiating teeth are moved to proper occlusion. In other cases there is only a barely perceptible repositioning anteriorly. In these latter cases we routinely institute the mechanical procedures indicated for the correction of the malocclusion.

It has been observed that, in the attempt to correct Class II, Div. 1 displacement cases with extraoral therapy, we may complicate our problem by tipping our maxillary first molars into a greater interference pattern with the mandibular teeth. This initiates more retraction of the mandible. We see our maxillary teeth move slightly distal, but their relation to the mandible remains unchanged as the latter is further retruded.

Oft times in our extraction cases, inadequate anchorage preparation will permit the tipping of teeth about the extraction site. This may bring certain

cusps into the freeway space and result in an orthodontically created displacement. Here again we see our anatomical relations become more severe or remain unchanged as treatment supposedly progresses.

One final potential problem relating to displacements may not occur until several years after treatment. Reference here is made to those cases wherein we have finished the occlusion to an anatomical ideal with minimal overjet and overbite. The retainer is left in place and periodic retention visits with static checks of the occlusion indicate all is well. However, time and growth are against us and, in time, the patient complains of sensitive incisors, sore temporomandibular joints, and painful masticatory muscles. These are the cases wherein we have had some latent mandibular growth. The maxillary incisors have been unable to tip labially because of the retainer which is worn at night and the musculature has displaced the mandible distally or laterally to avoid trauma to the teeth. This adjustment was satisfactory for a time, but growth finally succeeded in passing accommodation and then the teeth were traumatized. The muscles attempted to retract to a greater extent resulting in muscle fatigue and spasm. The joints were made sensitive to the strain on the ligaments created by the muscle retraction initiated by the tooth contact.

Summary

A neuromuscular basis exists for a response to premature tooth contact. These premature contacts may occur as the result of early finger and thumb habits, aberrant eruption of permanent teeth associated with overretained deciduous teeth, rotations of certain permanent teeth, tipping of teeth about an extraction site, faulty restorative dentistry and improper orthodontic control of tooth movement. The prematurities created by these and other oral factors prompts a repositioning of the mandible away from the high tooth, or teeth, to an occlusal position of maximal contact. This mandibular shift is detected only by a discerning orthodontist utilizing a dynamic diagnosis. The early correction of the functional problems will permit a more clear evaluation of the structural problems of his orthodontic case.

Conclusions

(1) Mandibular displacements do exist and their direction of displacement is the result of anatomic relations (static) and neuromuscular response (dynamic).

(2) The degree of displacement is difficult to assess longitudinally on a patient because of the influence and effect of growth.

(3) A recognition of occlusal dynamics should not be left until after the orthodontic correction is completed, but rather the dynamics of occlusion should be considered throughout the entire treatment and retention period.

Any professional science as exact and demanding as ours, of necessity, must have basic guiding concepts. Ours is acknowledged to be deeply steeped in mechanics and that which has preceded is not intended as a critique of this mechanical background of orthodontics, but rather as a caution, lest we forget the principal purpose for, which the teeth have been moved, and that is or should be — improved function.

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Discussion

Dr. John R. Thompson

These are both excellent papers. The first, Dr. Perry's, is based on research done at a university and Dr. McIver's* is the result of investigations carried out in an orthodontic office without the oft spoken advantages of university facilities. Dr. McIver has demonstrated that competent research can be mixed with a busy orthodontic practice. Actually there are some advantages to office research in that there is better control of the study material and continued availability of the subjects for reevaluation. I hope that Dr. McIver will continue to observe and to make records on these patients so that the cross-sectional studies will be enlarged to become serial and hence increase in value. Conditions that exist in a twelve year old may be different at fifteen.

I do not understand many of the anatomical terms used by Dr. Perry but I do know that this approach to occlusion of the teeth is important. It represents a transition from the mechanical to physiological. It is a step in the direction of thinking of teeth, not only from the point of view of esthetics as they appear on models, but also how they function. A malocclusion is classified as such since it deviates from the ideal anatomical occlusion but it may function quite efficiently, hence, it is a good physiological occlusion. After orthodontic treatment a fine anatomical or ideal occlusion may have been attained but function may not be as good as it was previously, thus it is a poor physiological occlusion. Our thinking must be expanded to evaluate the occlusion in its functional relation to the temporomandibular joints and the musculature of the head and neck. Dr. Perry has made it quite clear that this mouth of ours is not an articulator. It is alive — it is responsive to normal and abnormal stimuli. The position and movements of the mandible are controlled by stimuli recorded in the nerves of the periodontal membrane, joints and muscles. Changes in the occlusion alter the position of the mandible neuromuscularly as well as mechanically.

There are many splendidly treated cases being exhibited in the other room. A high degree of success has been attained in many in so far as interdigitation of teeth is concerned, but there are indications in some that the occlusion may not be in harmony with the temporomandibular joints and musculature. This is not a criticism. I cannot place myself in the position of a critic as I have experienced all of the unpleasant experiences associated with orthodontics as have you, but it points to the complexity of our task as orthodontists and we must not be content with our current way of thinking.

You who are listening may very sincerely say, "I haven't been bothered with clicking joints or muscular problems". If this is your opinion, then ask yourself whether or not you really have a basis for this statement. Possibly you have not looked; you may not have palpated the joints; you may not have placed your fingers in the ears to note crepitus; you may not have felt the teeth and listened as your patients have occluded their teeth repeatedly; you may not have observed the muscles on one side contracting before their fellows as occlusion is attained unevenly. You do not need a cephalometer or electromyograph but what you do need is the patient and the basic understanding of the structures involved, along with the motivation and desire to apply a functional analysis. This must become routine procedure in all orthodontic practices.

*Dr. McIver's paper was published in the October, 1959 issue.

We need not be frightened by Dr. Perry's remarks to think that we must now delve deeply into the complicated subjects of neuroanatomy and neurophysiology, but we do need to be aware of their implications as taught to us by those clinicians who have studied them in detail. Someday these subjects will be important in the dental curriculum along with clinical application of applied anatomy and physiology of the stomatognathic system — every bit as important as the technical subjects of dentistry and orthodontics.

Dr. McIver has been very fair in his appraisal of a complex subject — the position of the mandible. He has not entered this investigation with the objective of proving something. If we look hard enough, we can always find what we wish to find. The problem has posed a challenge to him and he decided to investigate it.

Dr. McIver has stated that the rest position is unreliable in an analysis, particularly of forward mandibular displacement or the "protrusive bite". This is quite true but the evidence offered to support this contention represents a variation in the rest position. Under abnormal muscular conditions the correct rest position cannot be shown but, when normal conditions are established and the symptoms of pain and strain are eliminated from the musculature and joints, the correct rest position is possible. This variation is seen frequently in complete denture cases. It represents a pathological variation in rest position and is not evidence as to the unreliability of the concept.

Likewise it is pointed out that the retruded position is not always reliable. At this time it is well to say that neither the musculature nor the joints are reliable guides to mandibular-maxillary relation under abnormal conditions. Both are quite dependable under normal conditions.

The rest position of the mandible is still important even though it is agreed that it is not an exact method of analysis, but is there any exact and positive method of analysis in use today? No— not now or ever. There is no such thing, and after one gathers the desired case records, the final analysis will be the interpretation of the individual mind.

Dr. McIver mentioned that many individuals with excellent functioning dentitions have a retrusive range. That is in accord with our observations and also those of Posselt and Beyron whom he has quoted. In his excellent group studies McIver states that, "eighty per cent of adults can retrude slightly beyond the intercuspal position". Also he observed that "seventy-three per cent of the Class II malocclusions could not retrude beyond intercuspal position while seventy-six per cent of Class I cases could not retrude". One might interpret this to mean that some of the malocclusions were in an abnormally retruded occlusal position and thus, a retrusion was not possible.

His further investigations of ten persons with excellent dentitions who could not retrude and ten others who could retrude point out that there is normal variation in function as well as in morphology. People insist on being different from one another. It is important to note that in both groups, while the posterior structures of the articular fossae may vary, the anterior relations of the condyles to the eminentiae articularis, the functioning areas of the joint, are identical.

Our objective in treatment of a Class II, as Dr. McIver has emphasized, is to establish an occlusion at or near the most retruded position. Whether or not there is some retrusive movement from the maximum occlusal position is not important as long as joint function is normal and the mandible is not deviated by the dentition into an abnormal occlusal position. Whether we can achieve this in seventy per cent of our

patients is not established and such group figures or statistics are not as important as checking each individual patient as to his function. It is of little good to have an individual occluding at his most retruded position if his temporomandibular joints click and snap. This is just as serious or more so than the individual who is deflected into a slight forward position to attain occlusion.

I believe that we do have to fear introducing an abnormal retrusive position in many of our cases. In the treatment of protruding maxillary incisors, they are retruded to reduce the overjet. I have on occasion moved these teeth too far to the lingual at too early an age and have caused a mandibular retrusion and clicking of the temporomandibular joints. In treatment of a malocclusion a good anatomical occlusion may be established at say the age of fifteen and this occlusion may be in harmony with normal joint function. But should mandibular growth proceed at a more rapid rate than maxillary and in a more horizontal direction, a traumatic incisal relation would be created. This would, as Dr. Perry has explained, stimulate a mandibular retrusion. Actually, individuals can grow into retrusion or posterior mandibular displacement long after treatment has been completed.

Dr. McIver has outlined his treatment procedures quite adequately. With these I have no quarrel and I would be pleased for my children to receive his treatment.

Dr. Alton W. Moore

I enjoyed these papers very much and commend the authors for their efforts. In my discussion I will attempt to consider them as a unit rather than separately in that their subject matter is interrelated.

The first thing I would like to point out are some facts that were brought out by these essayists. Dr. Perry pointed out that the mandible at rest position may translate backward and upward when the mandible moves into full occlusion. On the other hand Dr. McIver states that after the teeth have arrived in full occlusion, the mandible may be translated even farther distally into a more retrusive position.

These three positions, rest, occlusion and the most posterior position that the mandible may assume in the glenoid fossa are recognized facts. It has been reported many times in a group of patients with Class II malocclusion that recording the rest position and occlusal position of the dentures cephalometrically will show that some patients exhibit a translation of the condylar head posteriorly from rest position to full occlusion. Other patients, and sometimes the same patients, will exhibit the ability to translate the mandible even farther back from its full occlusal position through mechanical stimulation.

These are facts that have been observed and reported many times in the past. We cannot dispute these observations, however, there is no accord whatsoever in the interpretation of what these facts might mean clinically to the orthodontist. Several questions may be raised that complicate the making of a correct clinical interpretation of the significance of these observations. Some of these questions are posed here for your consideration.

What effect does growth have on these condylar relationships as an individual grows over a period of time? As yet this question remains unanswered because there has not been a sufficient number of studies of different age groups or serial studies of the same children to show what effect growth itself may have on condylar position.

Another question that may be raised is the effect that age may have on condylar position. Is the evidence of condylar translation as important in a

thirteen-year old child as it is in the adult? Or is the reverse true? We have all recognized temporomandibular joint symptoms in the form of pain and muscle spasms in the adult. I personally have not observed them in my own patients, who are of a younger age group, but this may be due to the fact that I have not been looking for these symptoms as was previously pointed out by Doctor Thompson.

Another question, is there a relationship between these mandibular positions that can be recorded and the symptoms that we have presented to us by our patients? Can a certain amount of condylar translation be considered normal? We know that there is a range of normal variation in the interrelationship of other parts of the body, so isn't it logical to assume that such may be true for the temporomandibular joint? However, the question of how much translation is within the normal range is yet to be answered.

Another limitation that is placed upon our correctly interpreting the clinical significance of condylar translation is the fact that we record these positions in two dimensions when we are dealing with a three-dimensional subject. We also record only one temporomandibular joint at a time and I am not aware of any studies where an attempt was made to correlate the records of the temporomandibular joint relationship on both sides of the patient.

Electromyography research has produced graphic recordings that illustrate muscle activity. These recordings are real and in many instances are reproducible on the same individual as well as different individuals. The clinical significance of these recordings is, however, open to multiple interpretations. A hypothesis may be formed as to how these records correlate with the clinical picture. The hypothesis must be tested clinically and correlated with other methods of measuring before a sound concept can be constructed. Until this is done we are still dealing with various viewpoints that may or may not have clinical significance.

My own observations and reading have led me to believe that we have observed many facts and have developed several hypotheses, but we have not as yet reached the stage of a positive working concept. The interpretation of the transitory positions of the mandibular condyle may differ one person to another. We may feel that the correct position is the most posterior retruded position and that anything forward of this is an anterior displacement, or we may interpret that the anterior position is correct and anything posterior to this is a distal displacement of the mandible. As yet we are still in a position of attempting to correlate our clinical results and observations with the records we obtain from our various measuring devices.

It has been observed that some patients exhibit a forward rest position and the condyles translate upward and backward as the mandible is moved into full occlusion. However, following orthodontic treatment it is later observed that the rest position and the full occlusion position of the condyle are the same. What occurred? Did the rest condylar position move back to the former occlusal position or did the occlusal position of the condyle come forward and become synonymous with the rest position? Frankly, I don't know the answer to this question but I do know that when I have observed this occurring in some of my patients that the mandible cannot be retruded any more by forceful means. Some may interpret this as evidence that the occlusal position of the condyle is the correct one; however, we cannot prove this because the effect of growth in the temporomandibular joint region makes exact interpretation impossible. Further

study will have to be executed before we can be dogmatic in regard to our interpretations.

Perry's electromyographical studies are an attempt to explain temporomandibular joint function on a physiological basis. Much is known about the growth and microscopic anatomical features of the temporomandibular joint and controlling musculature. Correlating this information into the total physiological picture of the function of the mandible should be relegated to interpretation at this stage of our knowledge. Such studies should not be disregarded because we are not able at present to apply the findings in our clinical practice. In the future as we gather more information these observations will help round out the complete picture.

At the present time I find myself at a loss when I attempt to analyze the significance of the rest position of the mandible to the clinical analysis of my patients. Twelve years ago when I first went to the University of Washington I was not in such a quandary. I told my students that we had true Class II malocclusions, as well as false Class II malocclusions which exhibited Class I molar relationship at rest position. After a few years of observing our clinical results, a study was conducted in which condylar translation was not found in most of the treated Class II malocclusions. In those individuals where translation still existed between rest position and full occlusion, a dual bite was present. These cases we felt were unsuccessfully treated. This, of course, is a matter of interpretation. In my experience, very few patients who exhibit a Class II malocclusion at the start of treatment correct their molar relationship in a short period of time. I was going to say that I have never had one exhibit this phenomenon, however, recently such a case presented itself in my own practice. Within a few weeks time this patient changed from a Class II molar relationship to a Class I. I found it impossible to forcibly move his mandible distally even when he was completely relaxed. The answer as to what occurred in this particular patient is unknown to me. It is only through such studies that have been discussed today that we will find the answer. We are increasing our number of known facts and I hope that sometime in the very near future we will have enough information to evolve a concept that will be clinically workable in the analysis and treatment of our patients.

At the present time I am personally analyzing all of my Class II malocclusions with the mandible in its most retruded position. I find that from a standpoint of recognizing the severity of the problem facing me that this seems to be the most realistic approach. I have more or less given up the rest position of the mandible in the analysis of malocclusion when I am evaluating the severity of the problem or the eventual prognosis of treatment.

In closing I would like to take one exception to a statement made by Dr. McIver in his paper which is as follows: "It is my belief that most Class II non-extraction cases need not be started before the late mixed dentition period when there are perhaps two or more deciduous teeth remaining. Early mixed dentition treatment with bite plane and headgear is all right if there is no objection to four or five years of care, but most of these cases require full appliance if satisfactory results are to be achieved."

I take exception to this statement because I feel that the reverse is true. The material presented by Dr. King in his analysis of mixed dentition treatment is additional evidence supporting the early treatment point of view. The advantage of treating children during their active growth periods, I feel, is well established and I personally have

no objection to treating my patients for a four or five year period if it becomes necessary. In fact, I have several patients who have been under treatment with headcap therapy for six and seven years and I am proud of the results achieved. I feel that the results achieved in these cases have produced the best physiologic occlusion, the best harmony and the best balance of all of the associated structures that was possible for the individual. The length of treatment doesn't concern me especially when it can be accomplished more simply with less time expended upon my part even though treatment has extended over a longer period of time. I feel that the child has benefited more from such treatment and I have not had any trouble with cooperation from these patients.

In my opinion the length of time that an appliance must be worn should not be used as a criterion of what type of treatment procedure should be utilized. We are dealing with growing children, some growing much slower than others, others growing more rapidly. The ones growing rapidly are going to respond more rapidly to treatment. Those growing slower will likewise have a slower response to treatment. Granted we can "horse" teeth around in a short period of time; but is this going to give the best balanced and stable denture for the individual throughout his lifetime? I seriously doubt that treatment time should be a factor as to what treatment procedure might be used.

In closing, I would like to again thank the essayists for their presentations. They have made a very important contribution to the overall problem. I agree with the facts that have been reported but I do not necessarily agree with the interpretations that have been made concerning their clinical significance. I respect the opinions of others, but I will not necessarily agree with them until they have been scientifically nailed down and their usefulness clinically proven.

Dr. C. C. Steiner

In the beginning, I was alarmed when I found myself faced with the prospects of discussing a paper titled "Physiology of Mandibular Displacement", by Dr. Perry, a teacher in the School of Dentistry, Northwestern University, and in participating in a panel discussion of that paper with the professors of two orthodontic departments of leading dental schools. I am sure that you expect of me, a strictly clinical orthodontist, a discussion of the clinical aspects of the subject of mandibular displacements.

First, let me say that Dr. Perry's paper is beautifully written, it was nicely presented and it reflects careful and expert assessment of a wealth of research material. If I understand a number of the statements in his paper, we do have some differences of opinion regarding a few of these beliefs. I do not feel, for instance, that the rest position is necessarily constant over a lifetime and I do not believe that it is a logical base from which to judge mandibular displacements. More specifically, if the mandible does close upward and *backward* from the rest position instead of upward and *forward*, which is usually regarded as being normal for it to accomplish maximum occlusion closure, I do not believe that this action necessarily implies mandibular displacement of the mandible in this position of closure.

I agree with him that mandibular displacements do occur and that generally they are the results of dental prematurities which may and very often do exist in all classes of malocclusions and in connection with other pathological conditions.

Dr. Perry said, "One segment of this subject of difficult cases which is worthy of consideration contains those cases wherein there may exist a significant difference in the maxillary-mandibular relations when examined statically on the one hand and dynamically on the other."

He also said, "Thompson has illustrated the constancy of the rest position. His original hypothesis of stability has been altered to acknowledge the effect of disease".

Dr. Thompson's discussion this morning makes it certain that he believes as I do, that the rest position can be altered by changing its environment. I accept, as he does, that the rest position is a constant under constant conditions.

Quoting Dr. Perry again, "The basic philosophy of rest position remains sound even under direct electrical studies of the muscles themselves and the radiographic studies of the temporomandibular joint in articulation."

To establish the normal path of closure from rest to occlusion, Dr. Perry quotes Boman as follows, "Boman studied normal occlusions in which eighty-eight percent of the sample closed upward and *forward* from rest position".

Dr. Perry states, "Ricketts utilizing direct laminagraphic x-rays showing the temporomandibular joints determined that two-thirds of his sample of Class II, Div. I cases before treatment exhibited a forward and downward movement of the condyles from occlusion to rest". (This would be an upward and *backward* movement from rest position to occlusion.)

Using the cephalometric methods that I have suggested, we have found that two-thirds or more of our Class II, Div. 1 cases close upward and *backward* from rest positions to maximum occlusion. This differs from the findings of Dr. Boman when he surveyed the closure of cases with normal occlusions.

Dr. Perry clearly states, "Fundamentally speaking, to accept the tenet that mandibular displacements exist, we must demonstrate that movement from rest to occlusion is along a path other than the accepted normal".

I must infer, therefore, that he would regard the majority of the Class II, Division I cases and/or those that close from rest position to occlusion in an upward and *backward* direction as being mandibular displacements.

I regard a mandible as being displaced if it is functioning or is closed in a manner or in such position that causes the condyles to be out of harmony with the other parts of the temporomandibular joint. I believe that it is possible for a mandible to be distally displaced but that such displacements are rare and small in extent. I also believe that if abnormal conditions which bear upon the positioning of the mandible are normalized, then the normal positioning of the mandible will usually occur.

I accept that the rest position is a reality for each case and that it is a part of the general functioning activity of the denture as it exists at the time. I also believe that it changes as the conditions which dictate the functioning of the denture are changed.

As evidence that the rest positions of Class II, Division I cases are generally different from those of normal occlusion cases and that they practically always change when the Class II malocclusions are successfully treated, I offer the following cases in evidence. (slides showing the before and after treatment records of four Class II, Div. I cases were shown and explained).

I congratulate Dr. Perry on this excellent paper and I appreciate this opportunity to comment upon it.

Dr. H. T. Perry

Dr. Steiner has suggested that many of these differences of opinion could be ironed out if we were closeted together for a few hours in a room. Now he is a Dutchman and I am Scotch-Irish, and it is difficult to speculate what would happen in such a closed conference.

T. S. Eliot has said:

"Between the conception
And the Creation,
Between the emotion
And the response,
Falls the shadow."

Everything that has been said yesterday and today acts to illuminate the shadow and darkness which so often envelops us because of misunderstanding and semantics.

Displacements are a very controversial issue and we have all acknowledged their existence; however, we disagree on their incidence. I believe if we are to "boil it down", it comes back to the original tenet of what is the rest position.

Dr. Steiner has said, "I do not believe that the rest position is necessarily a constant over a lifetime, and I do not believe that it is a logical base from which to judge mandibular displacements."

In the first instance, I do not believe that rest position is inviolate or invariable within the individual — it will vary with disease, pain, fatigue and occlusal alterations in either the vertical or horizontal plane. The rest position, however, does have a sound physiological basis in the healthy individual as mentioned in the paper discussed by Dr. Steiner. In the second instance, occlusion with the muscles contracted is not a logical base from which to judge mandibular displacements because the mandible, in occlusion, is already at its terminal position. It must be emphatically stated that a properly assessed, healthy rest position is a more tenable base from which to judge displacements than the occlusal position. The reasoning behind this statement is that the tooth contact initiating the displacement prompts unilateral or bilateral muscular response to position the mandible to a maximal occlusal position. This latter position may be eccentric to the accepted, or habitual, path of closure and thus prompt inequal or imbalanced muscle contraction to obtain it. The musculature of the mandible at rest, in the healthy rested individual, is not directed by proprioceptive or tactile stimuli from the periodontal membrane and thus, without joint or neuromuscular disturbance, is most likely to be bilaterally balanced and sagittally centered.

Dr. Steiner states that he does not believe an upward and backward path of closure is abnormal. It is acknowledged that variation reigns supreme within and between individuals. Some individuals may have an upward and backward path of closure which is not abnormal, but from the research data and studies previously mentioned, we should not accept it as normal until we have proven first that it is not abnormal.

Dr. Steiner again states that two-thirds or more of his Class II, Div. 1 cases close upward and backward from rest to occlusion and from this he infers that I would say they are all mandibular displacements. Here it is wise to point out that the position of rest and the assessment of this position are all important to this discussion. An improperly or hastily determined rest position would result in an unacceptable or abnormal path of closure.

Dr. Steiner believes the same as I when he states, "------ if abnormal conditions which bear upon the position

of the mandible are normalized, then the normal position of the mandible will usually occur." But what is normal? It is that centric mandibular position which is attained and maintained by equal bilateral contraction of the mandibular elevators with maximal harmonious and simultaneous tooth contact, which results in minimal strain to the temporomandibular ligaments, capsule and disc. It is not a position attained and maintained by inequal muscle tension due to tooth prematurities.

There seems to be quite a divergence of opinion between those from the Western and Eastern slopes of the Rockies as to how the mandible behaves. I believe on the Western slope, and I say this in jest, you get more sunshine and rain, and thus nature grows things a lot faster out there. On the Eastern slope, we get much less rain and have to rely upon fertilizer.

Thomas Carlisle once said that "the moment that we become angry in controversy we cease striving for truth and we strive for self." I believe what has been said here this morning has certainly opened my eyes to other possibilities and avenues of thought. I want to thank the discussors for being as kind and as lenient with me as they have been. Finally, Dr. Steiner, you stated in your opening statement that you were "strictly a clinical orthodontist". There are none of us here who are any other than clinical orthodontists for that is the nature of our breed. There may, however, be some of us who have never been "graduated" and still cling, like the ivy, to the university walls, for we recognize orthodontics as a clinical science with a necessarily heavy, basic science foundation.