A critique of research of the posterior limit of the mandibular position

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One of the objectives of prosthodontics is to restore missing dental and oral structures in such a way that there is a harmonious relationship among teeth, bones, joints, and muscles. One of the most controversial aspects of this complex relationship has been referred to as centric jaw relation. If one cuts through the hundreds of individual and group efforts to define this three-dimensional relationship, there are primarily two concepts which are at odds with one another. At the same time, these two concepts have much in common. Both concepts have the same clinical goal, i.e., to achieve an enduring harmonious relationship among teeth, bones, joints, and muscles. Both concepts depend on clinical procedures to achieve this goal, and on clinical evaluation for the success of goal achievement. The two concepts differ in that one accentuates a hypothetical anatomic relationship, whereas the other accentuates a hypothetical pathophysiologic relationship. Because the actual differences between jaw relation records achieved under either concept may be, and frequently is, very small in any given patient, it may be argued that there is no significant difference between the two concepts. Yet, many dental clinicians are convinced that the recording of centric relation is one of the most important features in complete denture construction, and that such records should be minutely accurate, regardless of the posterior tooth form to be used.[1]

The anatomic concept states that centric jaw relation is the most posterior relation (a border position established by ligaments), whereas the pathophysiologic concept states that centric jaw relation is the most posterior unstrained jaw relation (a relation which usually is not a border position and is established by muscle action). The word "unstrained" has meant different things to different people. For this reason, some clinicians would like to eliminate the word, but the word has persisted for many years and was used in this recent, commonly used definition of centric jaw relation: "The jaw relation when the condyles are in the most posterior un-

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strained position in the glenoid fossae from which lateral movements can be made at any given degree of jaw separation."[2]

The term "unstrained" is used almost in the sense of physiologic or normal, and its use implies that there can be a most posterior position which is not physiologic, not normal, but pathologic and undesirable. This concept is included in one recent definition of unstrained jaw relation as, "Any jaw relation which is attained without undue or unnatural force and which causes no undue distortion of the tissues of the temporomandibular joints."[2]

Nondentists who are exposed to the controversy concerning centric jaw relation are puzzled over dentists' great concern about what appear to be small differences. Their first thoughts are that the difficulty is largely semantic. There is no question that carelessness with the use of words has contributed much to the confusion concerning centric jaw relation, but, when good attempts are made to standardize and clarify terminology,[2, 3] it becomes clear that there are true differences in concepts concerning centric jaw relation.

The reason that centric jaw relation is important to dentists is that it is used as a reference position for the restoration of occlusion.[4] Error in establishing a physiologic reference position can be clinically disastrous, and the penalties of error are high. The most posterior position is said to be relatively reproducible and, therefore, a good reference position. However, reproducibility is not necessarily indicative of physiologic desirability or correctness.

For these reasons, the controversy is both real and important and has been the subject of considerable serious study. There are two types of study of this problem: (1) clinical success reports and (2) specific problem studies.

CLINICAL SUCCESS REPORTS

How does one measure the success of a complex clinical procedure involving many variables? In every clinical problem, there are patient variables and dentist variables, as well as procedural variables. Different patients have different diagnoses with varying degrees of pathologic involvement, and different adaptive capacities. In addition, dentists have varying degrees of understanding and skills in carrying out any clinical procedure. Either the patient variables or the dentist variables may be greater than the procedural variables. To compound uncertainty as to the actual cause of success or failure, there is the time factor. On one hand, it may take a long time for an unsatisfactory result to be revealed because it may be temporarily concealed by the adaptive capacity of the patient. On the other hand, time may introduce new factors causing failure which have nothing at all to do with the original procedure.

Because of the large number of patient variables, it is risky to compare the results of two types of treatment in two different patients. Yet, the nature of prosthetic treatment is such that it is difficult to compare two types of treatment within the same patient. Most studies are clinical reports and not controlled experiments. Such studies usually report the results of using a certain procedure on a certain number of patients. Usually such studies do not compare the same dentist's results using a different procedure in another series of patients, nor do they compare the results of two procedures in the same patient. When success is reported with a certain pro-

cedure, it is not known whether another procedure might have had equal results. One recent study,[5] which attempted to overcome these problems by providing two forms of treatment for one group of patients, shows the complexity of such clinical studies because of the number of variables even within the two forms of treatment. In this clinical study, which was concerned with tooth anatomy (not centric relation), the results seemed to indicate that there was little if any difference between the results of the two forms of treatment. If there had been a difference, then the many uncontrolled variables would have been very confusing. One must be on guard against variables which cancel each other. In the final analysis, it must be remembered that the results were really in terms of clinical evaluation. Methods of clinical evaluation can be scientific, but how much better it would be if we had better measuring devices.

No attempt is made in this article to review the many clinical success reports.

SPECIFIC PROBLEM STUDIES

In addition to clinical studies of success or failure of a given procedure, there have been many studies that seek to study specific aspects of the general problem. The methods used for these studies include anatomic, graphic, radiographic, electromyographic, cineradiographic, and cinegraphic. Each method has certain advantages and disadvantages. For example, anatomic dissection of cadaver material can give little information about the infinite finesse of neuromuscular activity, but it can reveal much about the direction of muscle and ligamentous fibers and the location of stress-bearing structures. No one method can reveal all we need to know but, rather, each method provides bits of information which help to fill out the big picture. For example, electromyography is dependent upon a thorough understanding of the anatomy of the region being studied, the physiology of the neuromuscular system, and the kinematics of the stomatognathic system.

In attempting to make meaningful evaluation of any study of a specific problem, it is well to note the number of subjects and the controls. Many of the most thorough and sophisticated studies have been done on only one or two subjects. Some studies simply cannot have controls. Sometimes the equipment used introduces variables greater than the variation to be measured.

In trying to determine which structures limit the posterior movement of the mandible, many ingenious studies have been made. For purposes of organization, results of research studies will be used to attempt to answer four questions concerning the posterior limit of the mandibular position at the vertical dimension of occlusion.

1. Does soft tissue posterior to the mandibular condyles establish the posterior limit of the mandibular position? Anatomic studies agree that these tissues have insufficient body to perform this role. Sicher[6] has pointed out that there is a thick layer of loose and vascularized connective tissue posterior to the condyles. Such tissue is readily adaptable to movement, either forward or backward. Rather than being a protector, such tissue needs to be protected. The suggestion that this vascular tissue form a vascular cushion[7] seems remote, and has been refuted by a histologic study by Parsons and Boucher.[8]

2. Does bone establish the posterior limit of the mandibular position? Anatomic

studies of human subjects indicate that the articular surface is located on the crest and posterior slope of the articular eminence, not on the posterior wall of the fossa. Similarly, the surface of the disc which articulates with the temporal bone and the articular surface of the condyle faces anterosuperiorly, not posterosuperiorly. Zola[9] describes bilateral articular facets with raised craniodorsal borders on the medial walls of the glenoid fossae just anterior to the petrotympanic fissures. He states that although there are no typically concave surfaces with which the condyles occlude, the combined form of the medial walls of both fossae and the posterior slopes of the eminences form the equivalent of bilateral concave surfaces which face anterolaterally. He further states that the disc is thin over the medial pole of the condyle indicating that it is a functional region. However, other workers[10, 11] indicate that if a thin area occurs, other than in the central area of the disc, it is usually over the lateral rather than the medial pole of the condyle.

Numerous radiographic studies of living human subjects confirm the anatomic studies, indicating that there is a space between the posterior wall of the fossa and the posterior surface of the condyle in centric jaw relation.

3. Do ligaments establish the most posterior limit of the mandibular position? Perhaps the most convincing studies showing that neither bone nor retrocondylar soft tissue establishes the posterior limit of mandibular movement have been anatomic studies. These showed that the condyles could be easily pushed back to the posterior wall of the fossa once the temporomandibular ligaments and the lateral pterygoid muscles had been severed. It is interesting to note in all of these studies that *both* the temporomandibular ligaments and the lateral pterygoid muscles were severed. In earlier studies[12, 13] the muscles were cut first, leaving only the ligaments which then provided the border stops. In a later study[14] the ligaments were cut first, leaving only the muscles which also seemed to function as border stops, allowing a Gothic arch tracing to be scribed by extraoral movement of the cadaver jaw.

It is difficult to state unequivocally the relative importance of muscles, ligaments, and bone in the maintenance of the integrity of any given joint. Some joints, such as the hip, have close bony adaptation. Some joints have strong ligamentous attachments, such as in the triad of lumbar intervertebral joints.[15] Some joints, such as the shoulder, have much less bony and ligamentous support and depend much more on the muscular girdle around the joint. However, as Sicher[6] has pointed out, the integrity of joints is maintained by muscular action. When a person loses consciousness, the body goes limp due to a loss of muscular activity and all joints become more flexible to outside manipulation in proportion to the dominance of muscles over bony and ligamentous controls. For example, even the hip and spine can be manipulated more freely in the unconscious state within limits of bony and ligamentous controls.

Even within each joint, certain movements are more within the control of muscles, and others are more within the control of ligaments or bone. For example, the knee can be flexed at a greater than 90° angle, but extension or lateral movement is severely limited by a strong combination of bony contours, discs, tough ligaments, and powerful musculature. However, even here external manipulation is increased somewhat in all directions under general anesthesia and curare.

If one keeps in mind the contrast between conscious and unconscious bodies,

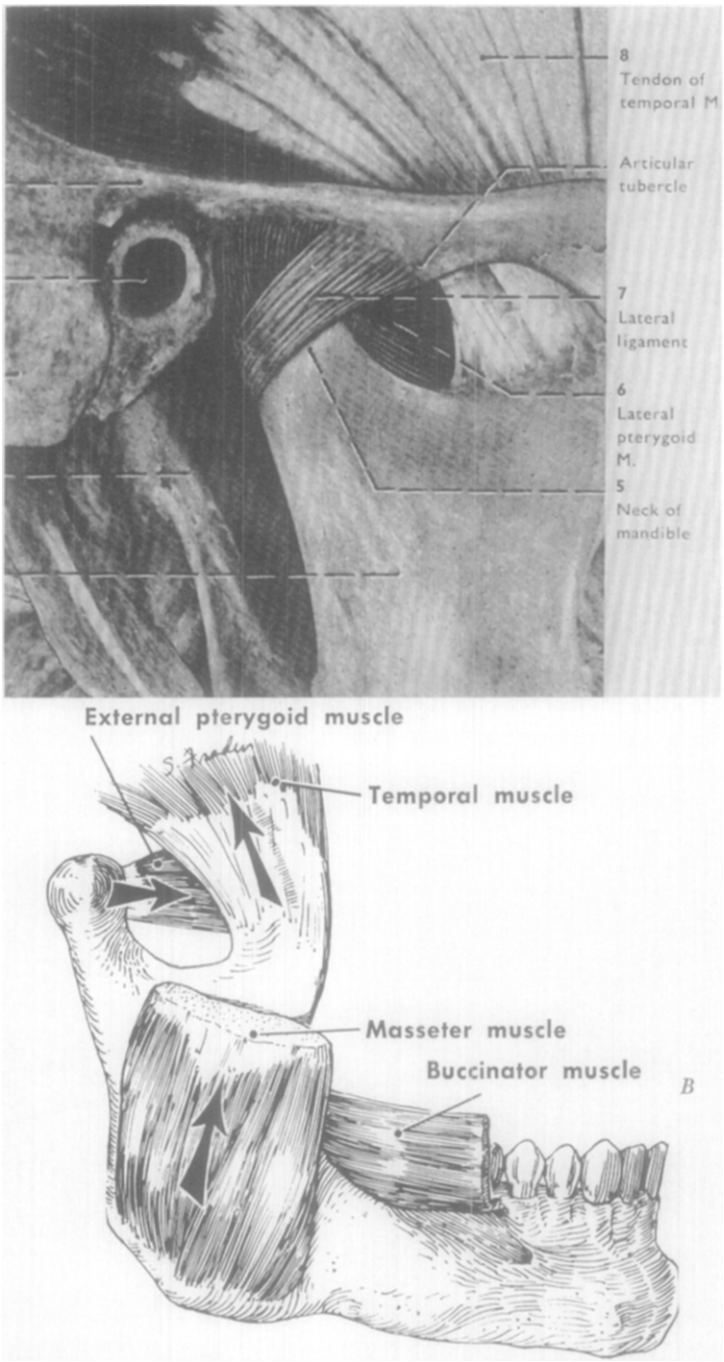

Fig. 1. The fiber direction of both the temporomandibular ligament and the lateral (external) pterygoid muscle is such that either or both could set limits to the posterior movement of the mandible. (*A* is from Zuckerman: A System of Anatomy, New York, 1961, Oxford Univ. Press, and *B* is from Nagle and Sears: Dental Prosthetics, St. Louis, 1962, The C. V. Mosby Company.)

one becomes aware of a basic concept about joints, namely that muscular activity maintains contact even at rest between articulating bones.[6] If this is true, then muscle is the first line of defense in the maintenance of the integrity of a joint. If this first line of defense is overcome by an outside force, check ligaments or bony contours are called in as secondary defense. Whether or not such a secondary defense is called upon depends upon many factors such as (1) muscular strength and direction of action, (2) bony contours, (3) size and direction of ligaments, (4) direction and strength of force, and (5) pathologic factors, e.g., torn ligaments, stretched muscles, and remodeled bone.

In the temporomandibular joints, the fibers of both the temporomandibular ligaments and the lateral pterygoid muscles pass in directions suitable for limiting the posterior movement of the mandible (Fig. 1). It seems probable that the lateral pterygoid muscles, acting in conjunction with the closing muscles, attempt to maintain a continuous contact (at rest, in occlusal position, in retrusive position, in protrusive position, and in lateral position) of the condyles through the discs against the articular eminences. Moreover, it seems likely that the temporomandibular ligaments cannot per se maintain the integrity of the joints in retrusion, unless the muscles fail to perform their role of maintaining articulation with the temporal bones or unless the ligaments are exactly the right length so that this temporomandibular contact is maintained. In other words, the functions of the ligaments and muscles may coincide, or the muscles may act first with the ligaments held in reserve, as a final check in the protection of structures posterior to the mandible, the degree of difference between the muscular and ligamentous positions being different for different subjects.

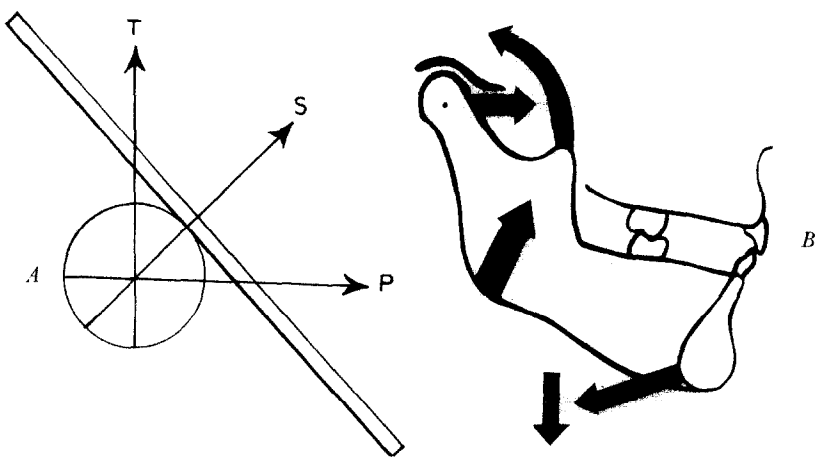

Fig. 2. One optimal arrangement of forces for the stabilization of a ball on the underside of an inclined plane (*A*) is similar to the arrangement of the muscle forces which maintain a continuous articular contact of the condyles through the discs against the eminences (*B*): Force *S* is holding the ball against the inclined plane; force *T* is pulling the ball upward at a 45° angle from force *S* to keep it from moving down the plane; and force *P* is pulling the ball to the side at a 45° angle from force *S* to keep it from moving up the plane.

4. Does muscle establish the posterior limit of the mandibular position? If one wished to hold a ball against the underside of an inclined plane, one would need forces in different directions. One optimal arrangement of forces is shown in Fig. 2: *S* represents the "sling muscles" pulling the condyle at right angles to the posterior slope of the eminence; *T* represents the temporal muscle pulling upward; *P* represents the lateral pterygoid muscles pulling forward. The combined tonus of these muscles tends to prevent the posterosuperior, posterior, or posteroinferior dislocation of the mandible.

There have been several studies which tend to support the hypothesis that muscle does establish the posterior limit of the mandibular position. The lateral pterygoid muscles are anatomically capable of the job, being short and powerful. Muscles resist stretching beyond a certain percentage of their length. A short powerful muscle can therefore be stretched only a relatively short distance due to both its physiologic and its physical elasticity.[16] Electromyographic studies[17] have shown activities of all these, including the lateral pterygoid muscle, during rest, in clench in intercuspal position, and in retrusion (Fig. 3).

In a study of one patient with the unusual pathologic condition of surgical paralysis of one lateral pterygoid,[18] the condyle on the affected side appeared in

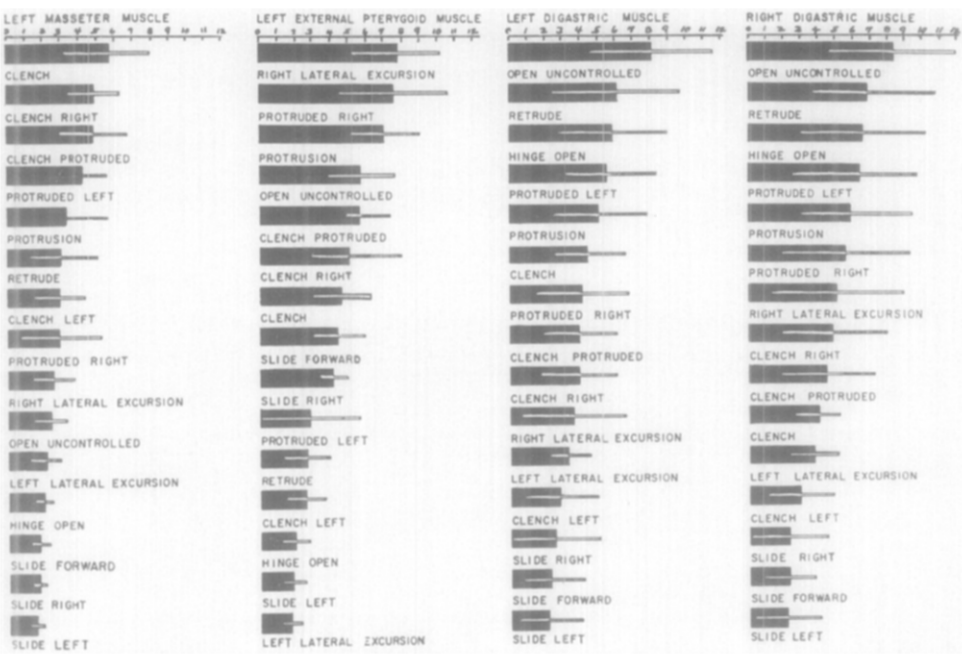

Fig. 3. An attempt at quantitative electromyography revealed activity of lateral pterygoid muscles in closure (i.e., clench) and retrusion, even though these functions are opposite the usually described functions of opening, protrusion, and lateral protrusion. If posterior occlusion is lost, the activity of lateral pterygoid muscles may be increased in clench. (From Woelfel et al.: J. PROS. DENT. 10: 693, 1960, Fig. 2.)

radiographs to be against the posterior wall of the fossa, whereas the unaffected side appeared to be in normal relation to the fossa.

Several clinical procedures have given suggestive evidence for the role of muscles in determining the posterior limit of the mandibular position. External pterygoid muscle exercises have been used successfully in the treatment of postural Class II malocclusions.[19] Various conditioning procedures such as stretch-relax exercises, premedication, and establishment of doctor-patient rapport tend to support the role of muscle in establishing the correct anteroposterior jaw relation.[20-22]

In the category of clinical success reports are studies of individual patients with

Fig. 4. The derivation of the word "unstrained" can be traced to such procedures as the use of an elastic chin strap to find the posterior border position. Some clinicians feel that such procedures produce undesirable strain. (From Lucia: Modern Gnathological Concepts, St. Louis, 1961, The C. V. Mosby Company.)

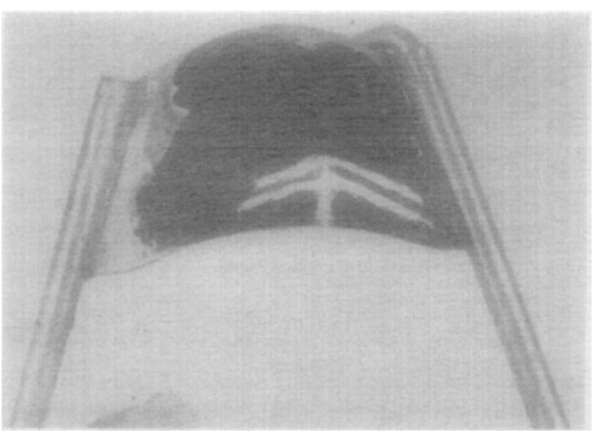

Fig. 5. A double Gothic arch tracing. The posterior tracing is made from a free closure position. The anterior tracing is made from the retruded position of the mandible. (From Hughes and Regli: J. PROS. DENT. 11: 18, 1961.)

temporomandibular joint pain–dysfunction syndromes, many of whom have been successfully treated by a forward repositioning of the mandible aided by muscle re-education.[23, 24] In fact, in some of these patients, the pain and dysfunction are probably the result of muscle spasm due to the overstretching of the lateral pterygoid muscles, as is suggested by the common finding of tenderness on palpation of these muscles.

The use of a chin strap or other devices to fatigue the lateral pterygoid muscles "in order to get the mandible back" has been used as an argument against the role of muscle (Fig. 4). However, it has been pointed out that muscles tend to fight against such unphysiologic forces and may do so asymmetrically.[25] Moreover, after using this clinical procedure, it is still impossible to know unequivocally whether the ligaments or the muscles were the limiting structures.

The ability of some patients to make two or more different Gothic arch tracings at the same vertical relation suggests the role of muscle in this procedure (Fig. 5).[26]

One might expect that maximum biting pressure would be achieved at a given vertical relation with the condyle solidly braced against the temporal bone. The fact that maximum power points have been found anterior to the apex of the Gothic arch in 35 per cent of a large group of patients would suggest that the intercuspal or maximal occlusal position need not coincide with the most posterior position in all patients.[27] Certainly it has been shown that a high per cent of "normals" can retrude their mandibles behind their intercuspal positions.[13, 28, 29] In a careful study of two patients with normal temporomandibular joints and full

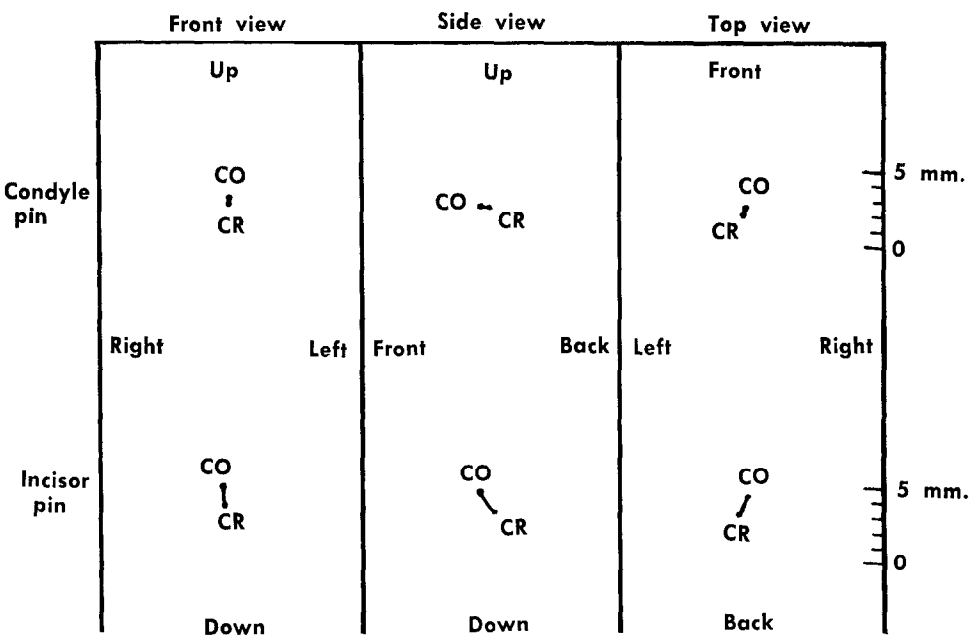

Fig. 6. Small movements in three dimensions of an intrabony condyle pin and an incisor pin during movements of mandible from (*CR*) centric relation (retruded position) to (*CO*) centric occlusion (intercuspal position). (From Hickey et al.: J. Pros. Dent. 13: 82, 1963.)

Class I occlusions, Hickey and co-workers[30] found small movements in three dimensions of a pin inserted in the condyle when the mandible was moved from the maximal occlusal position to the most posterior position (Fig. 6). Of course, as is clearly shown in Posselt's classic sagittal tracing (Fig. 7), retrusion from centric occlusion in patients with normal occlusions is impossible without enough increase in vertical dimension to clear cusp height. Only with nonanatomic zero degree occlusions is pure retrusion from centric occlusion theoretically possible at the same vertical dimension.

HEART OF THE CONTROVERSY

The problem of the desirability of the coincidence of the maximal occlusal position with the most posterior position is at the heart of the controversy. In the last analysis, all the discussion is for one purpose—to try to answer the question of where the mandible should be when the teeth are occluded. It is interesting to note that, even with all the accuracy and reproducibility attributed to the most posterior relation, considerable effort often must be made "to free-up the occlusion," "to mill-in the dentures," to create a "long centric," or to design "noninterfering" or "zero degree" teeth.

Using selective local anesthesia, Posselt and Thilander[31] blocked the receptors in the lateral portion of the capsules of ten young human subjects with normal occlusions. No effect was found on the degree of retrusion or on the Gothic arch tracing, but in the sagittal plane, maximal opening was increased 10 per cent in unilateral anesthesia and 15 per cent in bilateral anesthesia. (This effect was not observed when a placebo was injected.) Prior to this study, Posselt[28] had concluded that border movements were determined by ligaments. Even though no effect was observed on the horizontal plane in this study, the fact that any effect resulting from partial local anesthesia was observed suggests that the so-called border movements and positions may not be ligamentous but, in fact, may be muscular.

Perhaps the most decisive procedure by which to demonstrate the role of muscle

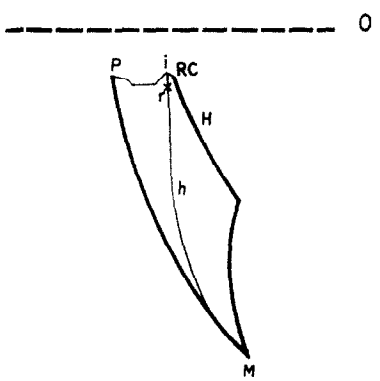

Fig. 7. The classic sagittal tracing of border movements shows that retrusion from the intercuspal position (*i*) to the retruded contact position (*RC*) necessitates a slight increase in the vertical dimension to clear cusp height. *P,* Protrusive position; *H,* retruded hinge movement; *M,* maximal opening; *h,* habitual closing path. (From Posselt: J. A. D. A. 56: 12, 1958.)

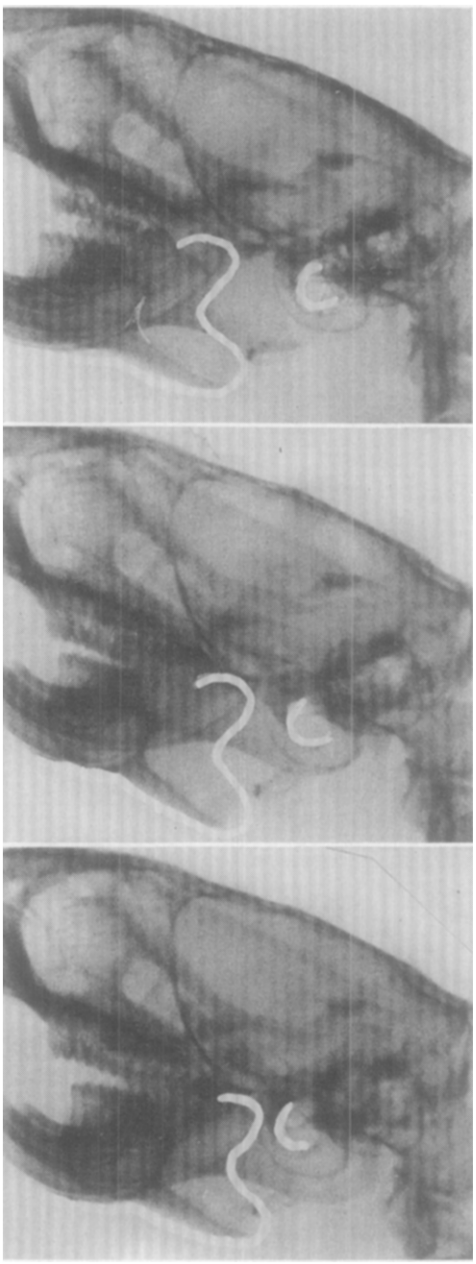

Fig. 8. Variations in jaw relations of a rat: Rest (*A*), forced retrusion under general anesthesia (*B*), and forced retrusion under general anesthesia plus curare (*C*). (From Boucher: J. PROS. DENT. 10: 1089, 1960.)

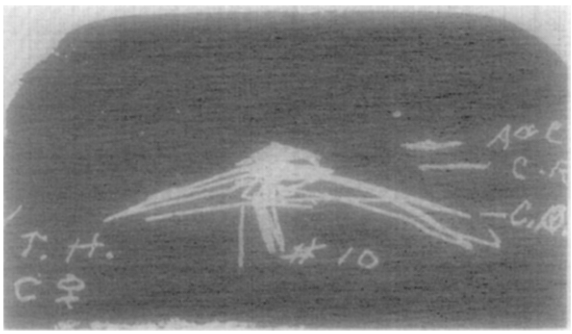

Fig. 9. Gothic arch tracings on one subject shows a more retruded border movement after the administration of general anesthesia and curare by an experienced anesthesiologist. (From Boucher: J. Pros. Dent. 11: 839, 1961.)

in the most posterior position is to administer general anesthesia and curare. Boucher[32] showed dramatic effects on animals with arthrodial type temporomandibular joints (17 rats, 1 hamster, and 1 rabbit) (Fig. 8). Posselt[28] studied one human subject before and during anesthesia and curare and found no significant difference in horizontal movement areas. However, Boucher[33, 34] studied 12 patients and observed that in 11 of the 12 patients under anesthesia and curare the posterior border was posterior to the conscious posterior border position (average 2 plus mm.) (Fig. 9).

Posselt's subject was a male dental student in his twenties with a complete dentition (at least 26 teeth) and no orthodontic treatment or occlusal adjustment, no periodontal disease, no temporomandibular disease, and no polyarthritis. Boucher's 12 subjects were randomly selected with no prior attention to inherent clinical variables. All of them had at least 10 teeth in each arch, and they were both male and female, both Negro and white, and ranged in age from 17 to 49 years. Certainly, the results of any clinical study will be dependent on the design of the experiment and the selection of the sample to be studied.[35] In evaluating such studies, it is important to know whether the patients had normal or pathologic joints and occlusions. It is a truism, often forgotten, that the adult edentulous state is pathologic and may have been arrived at after many years of various intermediate states of pathologic occlusions.[36] Depending on the history and the adaptive capacity of the individual, there may be many physiologic or pathologic changes in the temporomandibular ligaments, lateral pterygoid muscles, and even bony and joint configurations.[11, 37, 38] These possibilities enormously complicate the picture and make universal absolutes much less likely, no matter how earnestly we desire them. It is extremely unlikely that all patients will fall into one narrow category. Since the practical concern for centric jaw relation records is with abnormal occlusions, it is more likely that Boucher's subjects are more representative of clinical problems than Posselt's subject is.

SUMMARY OF PROVED vs. UNPROVED

It would appear that the posterior limit of the mandibular position at the vertical dimension of occlusion is usually established by structures anterior and lateral to the condyles rather than posterior to them. Both the temporomandibular ligaments and

the lateral pterygoid muscles are anatomically structured to perform this function. The lateral pterygoid muscles are in an excellent position to act as articular muscles to stabilize the temporomandibular joints in a way similar to the stabilization and protection of the small intervertebral joints by the multifidus muscles.[15] Because of their great adaptability and infinite finesse, muscles are capable of either working with or protecting ligaments. In fact, those fibers of the superior body of the lateral pterygoid muscle, which insert into the anterior part of the disc and capsule are well situated to help to stabilize the disc, the capsule, and even, indirectly, the temporomandibular ligaments.[7, 18, 33] Sicher[39] has used a highly descriptive synonym for muscles—"living guy ropes." Perhaps, in a large percentage of subjects, the lateral pterygoid muscles work in harmony and, for all practical purposes, simultaneously with the temporomandibular ligaments. Perhaps, in a smaller yet significant percentage of patients, the lateral pterygoid muscles, in conjunction with the jaw-closing muscles, are called upon to do the major portion of the work involved in stabilizing the joints. In such patients, the most posterior position is actually a pathologic position (a posterior dislocation), and the most posterior unstrained position is the physiologic position. None of this denies the common prevalence of anterior malpositions, but the possibility of posterior malpositions must be acknowledged.

Unfortunately, the solid research information supporting this hypothesis is still fragmentary. Much more needs to be learned. For example, the usual concept of the role of the temporomandibular ligament is that it acts as a physical or mechanical stop to the retrusive movement of the condyle. Perhaps its true role is more sophisticated than mere mechanics. The temporomandibular ligaments contain proprioceptive nerve endings susceptible to stretching.[40-42] Stretching of these ligaments could well lead to inhibition of the retrusive muscles (temporals and digastrics) and stimulation of the protrusive antagonist muscles (lateral pterygoids) (See Fig. 2). There is much more to learn concerning the neurophysiology of this region of the body, including the whole question of the absence of muscle spindles in the lateral pterygoid muscles[43] and in the anterior body of the digastric muscles.[44]

SPECIFIC SUGGESTIONS FOR FURTHER STUDY

The problem. What structures establish the posterior limit of movements of the mandible? Should maximum occlusion occur in the most posterior position? What is the range of normal variation? What is the range of pathologic variation? Under what conditions do pathologic changes take place? What is the measured effect on the posterior border position of specific muscle exercise, fatigue, health, age, psyche, specific malocclusions, head position, body position, specific types of jaw registration equipment, and many other possible factors?

Methods. Clinical success reporting is a legitimate research method for clinical problems. However, scientific methodology and thinking must be incorporated into the method. Adequate controls should be supplied. Variables should be reduced where possible or, at least, recognized and accounted for. The effect of patient selection must be carefully evaluated. Because of the difficulty of controlling the variables, larger numbers of patients are desirable.

Study of specific problems with the most sophisticated methods and equipment would be helpful. For example, computers may be used in handling of large amounts

of data in highly precise time measurements in neurophysiology, and in equipment such as a motion duplicator.[45] Cephalometric cineradiography synchronized with standardized electronic tracing devices would perhaps give more detailed information concerning such problems as the effect of anesthesia and curare on the posterior border position of the mandible. In all usage of sophisticated equipment, man must remain the master of the tool, no matter how impressive the equipment may seem to be.

In the last analysis, because there are many variables (maxillomandibular disproportions, neuromuscular tensions, occlusal abnormalities of varying lengths of time, adaptive capacity, and so on) and because these variables can occur in an infinite variety of combinations, it is unlikely that a single study will answer all our questions. However, a variety of studies will contribute to our understanding and will better equip us to meet the challenge of helping our individual patients.

DISCUSSION

In reviewing basic concepts and research on the posterior limit of the mandible, one thing is clear; whether we like it or not, the term "centric relation" means different things to different people. As an inevitable result, there is a strong tendency to avoid the use of the term.[46-52] The use of "centric relation" to mean a border position and not a central position has been one of its most confusing aspects. Other terms are being used and gradually accepted because they mean what they say. For example, there seems to be little confusion about what is meant by "terminal hinge position," "most retruded position," or "retruded position." On the other hand, although the term "ligamentous position"[48] implies a border position, the studies reviewed above question the use of this term as being based on an as yet unproved assumption.

If centric relation is thought to be coincident with the retruded position, then it is hardly central in a sagittal direction. Since centric relation has no clinical significance without occlusal contact, there appears to be a trend to substitute terms which are more descriptive of specific occlusal situations, e.g., median occlusal position, usual occlusal position, retruded contact position, and intercuspal position, some of which may not be harmonious positions because of specific interceptive or deflective occlusal contacts.

Thus, there still is a need for a simple term which describes the jaw relation in which the teeth, joints, ligaments, and muscles are in functional harmony and the teeth are in maximal occlusion, such as "ideal occlusal position."[49, 50] Many clinicians shy away from a term implying perfection such as "ideal" and settle for such terms as "median occlusal position,"[46] "muscular position,"[48] or "bracing position."[52] It will perhaps be some time before research will point the way to common terminology. Until that day, we must continually explain what we mean as clearly as possible.

Results of research can be confused by semantic questions of what was actually studied, as suggested by Graf and Zander.[53] Their study of preferential tooth contacts in intercuspal position as contrasted to the retruded position points to the value of precise terminology. Their study also emphasizes the individual variations of masticatory patterns among the five subjects. It is this individuality which provides the greatest challenge for more and continually better research.

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