Facial, Cranial and Cervical Pain Associated With Dysfunctions of the Occlusion and Articulations of the Teeth

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In a previous paper before the Mid-Western component of this society there were reported certain research findings noted in a three-year study of normal and abnormal functional activity of the temporal and masseter muscles[1]. One portion of the presentation dealt with the etiology, incidence, and correction of spasm in the muscles of mastication. The data for all of these studies was recorded with an Offner electromyograph. In most cases, unless otherwise specified, surface electrodes were utilized.

The electromyograph is a combination of electron tubes, rectifiers, batteries, fuses, switches and wire circuits. This device is capable, through the ability of the electrical engineer, of amplifying very minute electrical voltages to a recognizable level.

Muscle tissue is the sole locomotive means of the human body. The work in muscle is delivered with contraction. A contraction is a shortening or attempted shortening of the muscle fibers. The many fibers in a muscle are joined to form functional teams. The number of fibers in each team or unit is dependent upon the work requirements of the muscle. The greater the life-long work that a muscle is designed to do, the greater will be the number of fibers in each team. This functional group of fibers is referred to as a motor unit and each motor unit is, therefore, a group of fibers acting under the command of a single motor nerve.

Upon arrival of the neural impulse from higher nervous centers to the motor nerve, the entire group of fibers contracts as one. This contraction wave has its own characteristic features, one of which is minute electrical discharges. The electrical output is the result of chemical and electrolytic variations accompanying the physical change of contraction. These discharges normally occur when the muscle is active, hence they have been termed action-potentials. The occurrence of these electric action-potentials permits a study of active musculature with an electromyograph.

To record these action-potentials a lead must be placed on or in the muscle being investigated. This lead then relays any change in the electrical activity of the muscle to the electromyograph. Here the infinitesimal electric current of the active muscle is enormously enlarged. This amplification thus permits the investigator to record the electrical changes accompanying muscle activity.

The study of the muscles associated with mastication and other oral functions presents a myriad of neuro-muscular factors which contribute to the control of the varied movements and postures of the mandible. To ignore these factors which control oral function does not diminish their import, and a recognition of the major ones is a practical necessity when one attempts to understand oral function.

Practically speaking, all jaw move-

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ments are carried out by muscle contraction and normal muscle contracts only when stimulated by the nervous system. The movements of the mandible have two general levels of neural activation. The supreme authority resides in the highest level of the roof-brain—the cerebral cortex. It is at this level that all voluntary movements originate. If it is "decided" through "willed," "purposeful" or "volitional" activity to take a piece of food from a fork onto a particular area of the occlusion, some neural impulses are fired from the cerebral cortex into the internal capsule and through a distinct efferent pathway to the masticator nucleus of the trigeminal nerve out through the motor division of the trigeminal nerve, finally ending in the motor nerves to those muscles responsible for that specific "bite." There are several other participators assisting in the harmonious completion of this voluntary act. To mention only a few, we must include vision; the trunk, neck, shoulder, finger and arm muscles; the sense of touch in the teeth, lips, tongue and hand; and finally a special sense referred to as proprioception. Conscious mastication would probably proceed without the other contributing sensory elements, but without proprioception it would be a clumsy, difficult, and an uncoordinated task.

The second level of masticatory activity exists in what we might call the "basement of the brain," if we refer to the cortex as the roof-brain. This second neural level, guiding mandibular movement, is below the level of conscious control and is found in the brain stem. The area of the brain containing this control center is anatomically referred to as the mesencephalon. This area is approximately one centimeter below and behind sella turcica, overlying the spheno-occipital synchondrosis. Since this center is below the level of our conscious awareness, it is reflex in nature.

A reflex is a basic neuro-muscular response. In its simplest form when a single sensory nerve is excited by a stimulus it propagates a nerve impluse towards a synapse. In the synapse center the impulse is transferred into a motor nerve and conducted to a muscle which contracts. This then is a reflex arc. It does not travel directly to consciousness and its action is known as a reflex.

Most mandibular movements are on a sub-conscious, automatic level. The hundreds of daily swallows of saliva, the changes of mandibular posture in smoking, breathing, talking, eating, and many other hourly occurrences are primarily reflex in origin.

We are all aware of muscles and their motor nerves, but let us consider the peripheral portion of the sensory component in this reflex arc. I have just stated that a sensory nerve is excited by a stimulus. In mastication where does this stimulus originate? The stimuli arise in the periodontal membranes, the soft tissues at the sides of the hard palate, the temporomandibular joints and the masticatory musculature. These structures all have sensory nerve endings which are proprioceptive in function.

What is proprioception? It is, roughly, an awareness of one's self. By means of this system the brain is made aware of what is going on within the body. It is a sensory system trained upon the functioning parts of the individual. Proprioception is concerned largely with the smooth function of reflex. Proprioception and reflex have an early protective purpose from both the phylogenetic and ontogenetic viewpoints.

Just how the proprioceptive nerve endings in the oral cavity assist and guide mastication is best described as follows. A morsel of food is placed in the oral cavity and onto the tongue. The tongue acts as a stoker, continually darting in and out between the occlusal surfaces of the teeth. With each opening mandibular movement the tongue swiftly stokes the larger pieces back onto the teeth. The proprioceptive endings in the tongue muscles keep it from being bitten by sensing the proximity of the teeth. The nerve endings in the periodontal membrane signal centers of the motor nerves of the masticatory muscles to relax as the teeth near occlusion or make the slightest contact. The cheeks bank and hold the larger particles on the occlusal surfaces allowing juices and smaller pieces to enter the buccal or lingual sulci. The tactile and touch systems of the tongue and the cheeks sort the larger pieces out for further crushing. The smaller pieces are passed to the back of the mouth. With tongue pressure of swallowing, a peristalsis-like wave sweeps these lesser particles into the esophagus.

The nerve endings in the temporomandibular joints and the masticatory muscles also send impulses to the special proprioceptor nucleus in the mid-brain and from there to the motor nucleus of the muscles of mastication. With the increased power demands of various foods more frequent and numerous impulses arrive at the motor nucleus from the periodontal membranes, temporomandibular joints and the musculature. This increased tempo of signals results in a crescendo of muscular effort sufficient to overcome the food resistance or until occlusal contact is obtained.

The protective nature of this entire system has been experienced by all of us. If in chewing, we accidentally strike the tongue or a piece of bone in our food, we are immediately surprised with the rapid cessation of chewing and reversal of the closing movement. It was not pain that caused the muscles to relax for we are not aware of it until a few milliseconds after we have stopped chewing. What did stop our chewing was a protective reflex—primarily tactile and proprioceptive in nature.

This, of course, is an unusual example of oral proprioception being brought to a conscious level. This special aspect of nervous function is continually active at a reflex level. The presence of ill-fitting restorations, whether operative or prosthetic, are man-made irritants and stimulants to a proprioceptive response. The occurrence of malpositioned teeth before and after orthodontic treatment is also a factor initiating altered functional patterns and protective reflexes.

In situations of sudden, acute stimuli, such as biting the tongue or a piece of foreign matter in the food, an immediate muscular adjustment is required. This does not necessitate a drawn out relaxation or contraction and it therefore may occur in a vertical direction — the mouth opens; the muscles lengthen under tension. However, when tooth and prosthetic interferences are continually present, the protective reflex is maintained by a constant proprioceptive barrage. This nervous impulse barrage results in a low grade muscular contraction which moves and holds the mandible away from the irritating interferences. The usual direction of this mandibular movement is in a horizontal plane; however, it could conceivably occur vertically.

The physiological response to this anatomical derangement of the occlusion may be either transient or continuous. In a temporary situation, due to a high filling which is later polished down or a malpositioned tooth which is extracted, the reflex arc is broken. The mandible returns to its normal functional pathway, determined by a balanced musculature and normal inclined plane relations.

If the situation is severe and the traumatogenic factors are constantly present, the physiological process of protection results in a pathological condition in the musculature. Metabolic products accumulate in the overworked muscles. These in turn are irritants to the muscle and a spasm results.

A problem in terminology has developed. Is this constant contraction of muscle to be termed muscular imbalance or spasm? While spasm is truly an example of muscular imbalance, it is not the only situation or condition producing muscular imbalances. Bacterial infections, bony changes, joint changes, muscular and nervous pathologies are all contributing factors to the all inclusive term, muscular imbalance. In the case of spasm, the usual etiological agent is considered to be a hyper-active nerve impulse; and certainly from the information we now have, this is the cause of the abnormal muscle patterns we have noted.

It appears that there are certain head and neck muscles more prone to exhibit this abnormal pattern of activity than others. The location of the stimuli producing occlusal interferences does seem to affect the selection of the muscles which respond.

Sicher has often described the masseter and internal pterygoid as power muscles[2]. He has demonstrated how their structure and location are suited to power development. Sicher has also shown the importance of the two-headed external pterygoid in mandibular and articular disc coordination. I like to think of the external pterygoid and temporal muscles as the fine working postural muscles of the mandible. Of course, the others assist in this function, as do the temporal and external pterygoid contribute in some fashion to the development of power in occlusion. However, the location and attachments of the external pterygoid are such that they do exercise a definite control over the movements of the mandible in lateral and anterior directions. The temporal muscle with its three groupings of fibers, extremely broad origin, and narrow zone of insertion is excellently suited for short, concise, postural changes of the mandible.

In cases with long-standing occlusal interferences, the temporal and probably the external pterygoid muscles are reflexly stimulated to reposition the mandible away from the areas of premature contact. In the great majority of cases the posterior fibers of the temporal muscle retract the mandible; however, a few cases of anterior or lateral repositioning have been noted. In these instances, the external pterygoids and temporals act together to alter the mandibular posture. These two paired muscles are ideally suited anatomically and physiologically for minor alterations in mandibular posture.

Should the functional interferences remain uncorrected and the reflex arc continue to function through the waking hours, fatigue and its metabolic products take their toll on the muscle. The muscle begins to exhibit electromyographic evidence of spasm; and with the spasm, the patient eventually experiences a dull, aching pain with an accompanying drawing sensation.

Healthy, resting muscle does not show any signs of innervation to surface electrodes[3, 4]. When muscle is at "rest," it is silent and even the activity of tonus is not noted. However, as soon as a very slight movement occurs, several motor units discharge simultaneously and the electrical evidence indicates activity. In patients suffering the pain and spasms associated with severe temporomandibular joint dysfunction, this continual, low-grade contraction of the muscle is recorded as activity at rest. Rightfully speaking, the patient with mandibular muscle spasm does not have a physiological rest position, in these patients as many different rest positions result as attempts to register it.

The pain these people suffer is real pain though its area of distribution may be varied. Some of the pain may be of the referred variety, but we will come to that later. The greater portion of the pain follows closely the topography of the muscle areas which exhibit the spasm. The sharpest and severest pain usually is anterior to the external auditory meatus; apparently true joint pain. Most of the patients complain of a dull aching pain over that portion of the temporal (and sometimes masseter) muscle which exhibits activity at rest. The pain in the temporal area extends posteriorly and superiorly to the ear over the posterior fiber area of the temporal and forward over the middle and anterior fiber groups. The entire muscle is painful in only a few instances; pain in the area of one fiber group seems to be the rule rather than the exception.

The drawing sensation that some of these patients describe is posterior and superior to the lateral border of the orbit and may seem to form a tight band around the superior limits of the temporal muscle. Apparently this a fascial or tendonous pain because no electromyographical evidence of spasm is found in these areas, and the subjective sensation is not one of pain but rather an irritating, drawing sensation. This same feeling has been noted, in some patients, to follow the lower border of the zygomatic arch.

Pain and spasm have been noted in the masseter muscles, particularly following painful subluxations of the temporomandibular joints. This spasm is more acute at its onset and probably is of an "immobilizing" nature. In certain arthritic disturbances, movements of a limb about the diseased joint result in extremely painful sensations. These sensory stimuli signal the motor nerves to the muscles responsible for movement. The extensors and flexors about the joint go into a state of sustained partial contraction to hold the limb in the fixed position which elicits the least pain. This contraction of the antagonists and the agonist muscles about the inflamed joint to limit movement is termed splinting. The rest activity noted in the masseter muscles after joint subluxations is most likely a type of splinting, limiting the degree of mandibular opening, until the functioning parts have recovered.

Another area of dull but aching pain is described in some cases as located "at the side of the throat," or "deep in front of the ear." Although conclusive evidence is not at hand, it does seem reasonable to suppose that this is from the external pterygoid muscle. Since the position of this muscle is such that surface electrodes cannot be utilized, needle electrodes have been used. Some irregular activity has been recorded, but to state unequivocally that it is spasm is rather difficult. Needle electrodes are direct and traumatic invaders of muscle tissue. As soon as the needle punctures the muscle's surface, fibers and nerve nets are displaced and the "status quo" of the muscle is violated. Certain electrical discharges from the muscle while the needle is present, are called injury potentials; they are artifacts which must be discounted or overlooked if the true state of muscle function is to be revealed. Since the level of spasm is so low, the presence of these injury potentials sometimes masks or even camouflages the existence of the spasm. This is, therefore, one reason why we have cautiously regarded any and all of our findings with needle electrodes.

Many of our patients with continual temporomandibular joint pain have complained of apparently associated deep neck pains. This pain extends from the superior nuchal line down the posterior of the neck onto the shoulder and scapula. The pain in most cases limits itself to the side which has the poorest functioning temporomandibular joint. The pain has occurred on both sides in cases wherein both temporomandibular joints are in dysfunction.

For a long time an explanation of referred pain was acceptable to us until a chance statement by a patient caused pause for reconsideration. In questioning the patient on the subjective symptoms of temporomandibular joint dysfunction, their words, at many times, will excellently describe the problem in an everyday language. This particular patient had temporal muscle and neck pain. She made the remark that her "head seemed to be pulled forward." This statement started a long series of chain reactions in memories' card file.

Brodie has long taught the importance of the cervical musculature in head posture and the chain-like relations of the muscles of mastication, hyoid and post-cervical musculature. In 1950 he compared these muscle groups to elastics so positioned as to hold the head erect on the vertebral column[5] and also showed where tension in one group could conceivably result in tension in another group.

Voluntary retraction of the mandible by the temporal muscles results in the contraction of certain post-cervical muscles. To test this, one needs only to retract his mandible and palpate the post-cervical muscles on either side of the occipital protuberance. This information is confirmed with the electromyograph. The physiological basis for it can be found in Brodie's tenets of the muscle chain.

Any movement of a part of the body about a joint is not limited; other muscles and other joints must brace themselves for the action. In the strong or sustained contraction of the temporals, necessary to retract the mandible, the balance or homeostasis of the suprahyoids is upset. These muscles come into play as the mandible moves and thus the hyoid bone moves.

The wave of muscle action sweeps from one muscle group to another to maintain head and neck posture and the visual axis. In the more severe or longer acting joint dysfunction cases this wave of muscle activity reaches the post-cervical muscles. These muscles contract to stabilize the offsetting nature of the pre-cervicals, hyoids and mandibular postural muscles.

It is definite that the strong contraction, characteristic of mandibular retraction, is many times greater than those recorded in spasms. However, the ever present, low-grade contraction of the spasm possibly is sufficient to call other muscles of Brodie's chain into action.

The effect of the continual retraction and gravity seems to be enough to call the post-cervical muscles into play to maintain head posture. Certainly if this is the case, some signs of muscle activity at rest should be noted in the post-cervical muscles in those patients complaining of neck pain. With the aid of surface electrodes spasms have been found in cases with more severe cervical pain. It is difficult to ascertain which muscle or muscle groups are responsible for the discharge because so many different muscles underlie the electrodes. It seems reasonable to assume that the semispinalis capitis and the recti capitis oblique and posterior are responsible, for these are the major extensors of the head.

Perhaps it is indicated, at this point, to offer a short resume of what has been said.

Muscle spasms at rest have been recorded from the temporal, masseter and post-cervical muscles in cases exhibiting gross functional interference of the occlusion and resultant temporomandibular joint dysfunction.

These particular spasms noted in certain of the head and neck muscles are believed due to a proprioceptive reflex arc from the periodontal membrane, temporomandibular joints and mandibular musculature. The posterior fibers of the temporal muscles contract slightly to withdraw the mandible from the maxillary tooth interferences present during functional movements. The physio-pathological result of this constant guidance is overwork. The overworked muscles eventually fatigue and in certain of the more severe instances a spasm occurs in the involved musculature. This spasm is present even when the muscle is attempting to rest. The continued absence of rest and the permanent nature of the spasm finally effects a stimulus of the sensory nerves of the muscle and the patient experiences the dull, deep ache of muscle pain.

In those patients wherein the temporal muscle retracts the mandible, the post-cervical muscles are often called into play to maintain head balance against the pull of the pre-cervicals, infra and supra hyoids. Thus the patient with ill-fitting dentures or high restorations truly has a pain in the neck because of his teeth.

All of this has seemingly wandered a long way from orthodontics and dentistry in general, but let us remember that these problems are of dental origin and dentistry can correct them. Thompson has long been a proponent of corrective dental measures for incorrectly functioning temporomandibular joints.[6, 7]. His methods of approach have been two. The first is with use of a test splint to reposition the mandible and re-educate an imbalanced musculature. The second treatment procedure is used singularly and in some cases in conjunction with the splint. Functional wax records are taken with the patient executing certain volitional mandibular movements. Points of prematurity in the occlusion are noted and ground away with dental stones.

To the patient and the operator, the test splint offers the most dramatic relief, but it should be remembered that the cases on whom splints are used are usually severely malfunctioning cases. Any improvement of function would seem enormous in these mouths.

The proper use of Thompson's functional wax method of diagnosing occlusal disharmonies will offer just as dramatic results in the relief of spasm and the improvement of muscular function. The improved function is not as strikingly apparent to the patient, for function has never been lost, only impeded.

With the use of splints or occlusal equilibration, the initial attempt by the operator may be effective only temporarily in relieving the pain and spasm. Further work must be undertaken at later sittings to completely eliminate the total disturbance. The old reflex arc is usually broken with the first attempt and the patient's tensions, malaise, and pain are rapidly routed only to return if the new position established by the splint or occlusal equilibration is insufficient.

At the present time there is no positive manner of locating a position of all around postural balance. The occlusal portion of the splint must be reconstructed to new positions until one of permanent comfort is established. This final splint is then used as a guide towards which the oral reconstruction is directed.

In the method of occlusal equilibration with functional wax records the occlusion is corrected over a three to six weeks period in the more severe cases. This allows the mandible to reposition itself and re-establish its physiological rest position and physiological pattern of function. As the mandible changes its posture with the cessation of the protective reflex, new and minor points of interference will probably be noted. These are relieved at subsequent visits using a soft, red base-plate wax as a registration medium. Gradually the musculature is re-educated by a smooth bombardment of nervous impulses as inclined plane meets inclined plane with a solid certainty. No longer do the teeth "jiggle and jog" over each other, as a car on a corduroy road. With the removal of the premature and initial contacts the musculature confidently guides the mandible with a smoothness of purpose and function that is characteristic of normal mandibular kinematics.

The importance of muscle in maintaining an independent life cannot be denied nor can it be overstressed. From the first contraction of the newborn's diaphragm and intercostals, filling the infant's lungs, to the final, fainting beat of a worn and weary heart, life depends upon muscle. Between each end of life, muscle plays a continual and dominant role in all of man's internal and external bodily movements. We as orthodontists need not concern ourselves with all of the varied physiology of muscle; it is important, however, to understand some of its principal functions which are so closely allied to our goal of treatment success.

The material presented in this paper is just a small part of an ever increasing endeavor on the part of dentistry to obtain more information on the relation of muscle to oral problems. It was not the intent of this paper to acclaim occlusal equilibration as the panacea for all head and neck pain nor to cast the musculature of this region into the role of a headache scape goat. It has been the purpose, instead, to point out the use of the electromyograph as a means of differential diagnosis of certain neuro-muscular disturbances and to demonstrate certain successful methods of correction.

The cephalometric contributions of the past two decades have made us more cognizant of growth and facial pattern in our treatment concepts. The electromyograph affords a similar means to sounder methods of treatment, from the functional viewpoint, by providing us with a better understanding of normal and abnormal muscle activity.

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