

# Treating Craniomandibular Dysfunctional Patients Implementing Gnathological or Neuromuscular Concepts

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*“Dentists should be doctors of the mouth.”-B.B. McCollum, 1924*

## Introduction

Treating craniomandibular disorders (CMD or TMD), is an area of dentistry that has often times frustrated the clinician due to its multi-faceted musculoskeletal occlusal signs and symptoms. An aspect that should be considered in this arena of treatment is the study of occlusion that relates the maxillary and mandibular teeth as well as the temporomandibular joints and the mandible to the cranium. Investigating even further into this arena of occlusion, one discovers that it also involves physiologic dynamics of muscle activity and muscle rest that drives the masticatory element of occlusion. It is the supporting element that is often overlooked in the health care field that allows the human body to posture and optimally function as a complete healthy system. <1> It is apparent after a more thorough understanding, diagnosis and evaluation by the dentist that musculoskeletal, postural, emotional, biochemical and/or functional issues may be part of the suffering patients complaints. <78> Many of the symptoms that accompany this disorder continue to challenge the great minds of the dental profession who may not be aware that the signs and symptoms which are presented go beyond the occlusal perspective of how teeth articulate and where the centricity of condyle to glenoid fossa relationship exists.

Traditionally it was believed that these disorders can be treated through gnathological occlusal principles. However, there are fundamental differences between gnathological and neuromuscular approaches in therapy when addressing the needs of patients who present with the numerous signs and symptoms that compromise the craniomandibular dysfunctional patient. These differences will be presented in this paper. A clinical case report will be presented and reviewed which has been treated gnathologically and later treated neuromuscularly implementing computerized electro-diagnostic and treatment instrumentation validating the often unrecognized differences.

## **Occlusion – An Extension of Posture and Muscle Dynamics**

Occlusion is an extension of general postural considerations that goes beyond the understanding of cusp to fossa relationships. It is a dynamic phenomenon that includes the afferent proprioceptive sensory input affecting the central nervous system mechanisms and resultant states of muscle tonicity. <2,3,4> It is a historic subject of study that has been made by dentists who have attempted to “measure” the mandibular component of dental occlusion from a static perspective, mostly utilizing various forms of mechanical apparatus to support and confirm their convictions, only to leave behind further artifact, inaccuracies and confusion of a bio-physiologic system. It is a fundamental element in dentistry that almost all departments of dentistry (prosthodontics, restorative, oral maxillo-facial surgery, orthodontics, periodontics, pediatric dentistry) are concerned with. <5> One of the key issues every generation of our profession has had to face.

In prosthodontic dentistry where the aim is artificial reconstruction of occlusion to harmonize with the entire stomatognathic system, two major schools of theory have been advocated: One is the mechanical occlusion theory initiated by Bonwill (1858), where emphasis is placed upon mandibular movement. <6,7> The mechanical occlusion theory has been dominant in prosthodontics over the past 100 years and has led to the development of numerous adjustable articulators, devices and related clinical techniques. The mechanical occlusion theory is based on a belief that the temporomandibular joints hinge on an axis of rotation in the glenoid fossa of the skull. <79> All occlusion is guided and brought together to a finely tuned order, determined by the axis of jaw joint rotation. <9 > The emphasis is on occlusion and TM joint position that has been fundamentally called "centric relation". <10,11>

The second occlusion theory is based on neuromuscular physiology, the functional occlusion theory. This theory indicates that the functional occlusion system is made up of four major components: teeth, muscles, nerves and temporomandibular joints. <3,79> Its basis of understanding is that the temporomandibular joints are in a physiologic rest position based on the guidance of muscles, neurally controlled and stabilized by the occlusion, all integrated with its peripheral proprioceptors and relax mechanism of the central nervous system. The emphasis is on establishing a physiologic relationship of the mandible to the cranium resulting in a neuromuscular rest position to support a physiologic established occlusion for stability of the jaw joints, the masticatory muscles of the head and neck, and the teeth with the surrounding periodontium.<8>

Both these philosophies have been strongly debated among clinicians who have been seeking the answers to the mysteries of occlusion with all its challenges that include the treatment and management of the mandible, the muscles of mastication, the supporting hard and soft tissue structures of the temporomandibular joints that make up the structural component, the nutritional, as well as the emotional factors that effect the patient. <79> Jaw joint position has been a major emphasis among the various schools of thought, with strong opinionated feelings to support each ones view, clinical experience and teachings they have received.<82>

Although this hinge axis position is the foundation to traditional occlusal diagnosis and treatment and advocates boast of its accuracy, precision, and repeatability,<12,13> experts continue to disagree where an optimal condylar centric and mandibular position is located. <10,14,15,16,76, 77, 80, 81, 82, 83> Pameijer has noted in his text, "It can be assumed that centric relation is not a continuously stable position of the mandible for any given length of time, but a position which is not in the least stable once the regulating influence of the neuromuscular mechanism and anatomical changes are taken into account."<11,17> He further states, "The discrepancy between centric relation and maximum intercuspation is a reality which every clinician performing occlusal therapy must accept. The question – 'at which mandibular relation maximum intercuspation should occur in order to obtain a harmonious entity with the neuromuscular system then needs to be answered.'"<18> Though this term "centric relation" is commonly used among the traditionalist still to this day, literature indicates that it continues to evolve in meaning. <83>

## Questions That Should Be Asked

The confusion surrounding occlusion theories in dentistry today only raise a fundamental concern about what position should the jaw joints be in when restoring the chewing structures of the mouth.<10> Many clinicians who have been faced with restoring full dental arches were also faced with questions such as:

1. What is the proper **vertical dimension** of occlusion and how can one determine it?
2. What is the **optimal condylar position** within the glenoid fossa since dental occlusion is connected to the mandible on one end and the joint at the other end?
3. What is the **optimal anterior/ posterior position** of the mandible when restoring the mouth and how does one determine it?
4. Is there temporomandibular joint **pathology present** even though the patient may not complain of pain?
5. How will a pathologic joint affect the clinician's treatment outcomes and occlusion?
6. What impact will **muscle tenderness** of the head, neck, face and shoulder regions have on treatment outcomes, short-term and long-run?

These concerns are surpassed only by the multi-factorial signs and symptoms associated with craniomandibular dysfunctions (TMD) that clinicians recognize or ignorant of the symptoms the patient presents with.<19,20> Although these concerns continue to plague our dental profession it becomes apparent that objective and measurable parameters must be implemented to begin to unravel the knot of confusion as to how best to begin a mode of treatment and resolve the opinionated confusion. The following four questions most pertinent in regards to the theory, the practice, or application (method) of occlusion in the daily practice of dentistry maybe asked:

1. Dawson insightfully has written, "Because muscle controls all function, the muscles must have a static resting relationship from which functional activity begins and returns." And he further states, "There can be no occlusal harmony when any part of the masticatory system is at war with muscles." <73 > What objective data can be provided to support the traditional mechanical theory of mandibular position to best ensure muscle harmony?
2. What accepted measurable physiologic standards are used by the clinician to establish the physiologic maxillo-mandibular position?
3. How does the clinician document and validate a patient's physiologic response to cranio-mandibular/ occlusal therapy?
4. Since every dentist has experienced patients developing clinical symptoms after minimal dental procedures, how can the dentist identify sub-clinical pathology that maybe exacerbated into full blown symptoms, ie, headaches, ear symptoms, joint noise, joint pain, atypical facial pain, neck aches, etc., after simple dental procedures?

## An Awareness of the Musculoskeletal Occlusal Signs and Symptoms

Musculoskeletal occlusal signs and symptoms are often overlooked by today's clinicians, not associating the structural-anatomical components with the bio-physiologic components (teeth,

masticatory/ head and neck posturing muscles and temporomandibular joints). Many clinicians may not be aware that these symptoms may impact the dentistry performed or dentistry that is performed may also contribute to craniomandibular disorders. Temporal pain/ headaches, frontal headaches, neck aches at the base of the cranium (suboccipital region), pressure feelings behind the eyes, fullness or ear congestion feelings in the ears, possible ringing in the ears (tinnitus), masseter muscle soreness, teeth sensitivities, decreased range of motion in jaw movement, serpigenuous/ deviating mandibular opening patterns, clenching/ bruxing, worn dentition in the anterior or posterior regions, narrow arch formations, vaulted maxillary palates, bicuspid drop offs, lingually inclined dentition, scalloped bordered tongue, deep over-jets and excessive overlaps of anterior incisors and bone loss are just a few of the many clinical signs and symptoms that can be observed by the astute clinician. <70, 94> Correlating these observations with jaw joint pathologies, mandibular posture in addition to an appropriate occlusal scheme to harmonize it to an optimal muscle physiology will contribute to resolving the musculoskeletally compromised patient. Whether the patient complains about these indicators or not, does not preclude they exist and contribute to craniomandibular disorders.

### **Posture, Muscle Balance and Occlusion**

The clinician must always be aware of the relationship between general posture and the posture of the mandible to the cranium during intercuspation. Changes at any level of the postural chain can create compensatory changes in the masticatory muscles. Conversely, changes in occlusion that alter masticatory muscle tonicity can create compensatory muscle changes at lower levels of the body.<66, 67, 68, 69>

When at rest the mandible is in a state of static equilibrium maintained by a delicate balance of muscles which are firing at low levels of activity. The dynamic sling of masticatory muscles will bring the teeth into occlusion during swallowing regardless of the demands upon the musculature. <85> The greater the malocclusion, the greater the muscle accommodation necessary to bring the teeth into maximum intercuspation.<86, 87, 88>

The human body is complex and functions best when balanced and placed in a neutral physiologic position. The supporting structures such as the pelvis, the shoulders, the cervical neck regions, the head and mandible should all support one another in this balanced environment. <89> Once a rested and optimal mandibular posture is objectively determined, the teeth and the occlusion can then be adjusted or restored as a treatment to correct and stabilize the balanced stomatognathic system.

### **Gnathological Therapy – *Legacy and Philosophy from the Mechanical World***

Some very innovative and forward thinking dentists who forged a broader perspective to dentistry in the early 1920's<21>, challenged the present beliefs and views of the time by broadening the perspective of what dentistry was about and refining mechanical measuring and recording instruments to understand mandibular movements as they related to occlusion. Some of these pioneering dentists and scientist such as McCollum, Stallard and Stuart realized that dentistry was more than treating teeth. They emphasized that a thorough diagnosis and understanding of the mouth as a functioning unit was the basis of gnathological principles. <21> “The human being is a complex system of biological processes, the understanding of which is the continuing challenge of medical science.” It is no less a challenge to dental science and was thus

expressed by McCollum in 1924.<21> “Dentists should be doctors of the mouth.” “All good dentistry is preventative medicine to the highest degree.”<23> It was through the inspiration of these broader views that the gnathological concepts were further developed and termed. Stallard a founding father of the gnathological concept defined “gnathology” simply as “the science of functions, the forms and the factors of all the activities of the main parts of the mouth”. <24,25> These dentists viewed this area of dentistry as a specialty of dentistry that concentrates on the entire *gnathic* system and the whole patient. <24>

The term "Gnathology" was first coined by Stallard in 1924 <21,22,26> to describe in its broader sense the study and treatment of the entire mouth as a functioning unit. It was also defined as the science that enables dentists to restore, protect and preserve the human dentition.<21> This term gnathology stems from the greek word gnathic or gnathos in origin referring to the jaw.<27 > The use of the word gnathology was purposely used to direct the attention of dentists to the importance of the jaws; not to minimize the importance of the teeth, but to elevate their significance as they related the biologics of the masticatory system; that is the morphology, anatomy, histology, neurology, bio-physiology, pathology and the therapeutics of the mandible and teeth as it relates to the stomatognathic system and the rest of the body. <22>

Stallard stated, "Gnathology includes the exact relations existing between the teeth and the morphological border movements of the condyles: the lateral, the anterior and the rearmost positions... and most importantly, gnathology includes knowing how the nine various directions the condyles move laterally and medially in vertical chewing movements. How the chewing cycle of cusp points may be related to centrically related cusp-fossa occlusion, is wanted gnathological knowledge."<21,28>

McCollum is credited with the discovery of the first positive method of locating the hinge axis and developed the first instrument capable of simulating mandibular movements. Later he developed the first instruments to record mandibular movements with Charles Stuart, 1930. <21,22> These mechanical devices were designed based on notions and opinions of persistent doctors who believed the jaw joints functioned in a certain particular hinging-rotating manner, thus influencing their understanding of dental occlusion, mandibular movement and jaw function. Their focus was the ‘chewing mechanism’ which comprises the mandible and the maxilla, the many associated bones of the skull, the teeth, the investing tissues, the major and minor masticatory muscles, the temporomandibular joints and their associated ligaments, as well as the salivary glands of the mouth as they related to the masticating process and digestive function..<29>

Although the mechanical approach endeavored to understand oral physiology and pathology of the mouth, due entirely to the mal-relations between opposing teeth and between the interdigitation of the teeth and jaw motions, they viewed these problems as *mal-articulations*. <22> These views emphasized that the biological factors of mastication and the physiology of the mouth were expressed in the teeth, thus the articulation of the teeth become the fundamental factor in their understanding of oral pathology. Thus their view of dental physiology and pathology focused on the mal-relations of the parts of the oral mechanism.<29> This belief unfortunately limits the understanding of how all parts of the stomatognathic system influences one another to maintain a harmonious balance. Today these views persist.

## **Traditional Dental Thinking Always Rearing Its Head**

Before gnathology, dentists had concentrated their attention in four major areas: treatment of dental caries, restoration of missing teeth, treatment of periodontal disease and prevention. <21> With gnathology, all of these efforts are tied together in the creation of a normal functional masticatory system. More than that, the gnathological goal was to integrate all the branches of dentistry to provide harmonious functional movements of the jaws as the goal of dental science. <21, 25> Even though these concepts strive to uphold the ideals of their medical counterparts as being physicians of the mouth, the fundamental emphasis toward a fixed mechanical aspect of teeth articulation continues to persist through time to the present day.

Fixed factors of gnathologic dental articulation as mandibular joint centricity, hinge axis location of the joints, character of the condylar path, angle of the articular eminence, lateral movements of the mandible, inclination of the occlusal plane, curve of Spee, curve of Wilson, character of the cusps of the teeth, dento-labial relations, overbite and over-jet, all endeavor to relate the teeth properly to each other in such a way that they could have a cooperative relation to the jaw motion.<22> It was taught that any treatment under this concept requires a basic diagnosis of the bio-mechanics of the masticatory apparatus. Due to the limitations in their understanding of the bio-physiology of the masticatory system they pursued what they viewed as an exacting gnathological diagnosis which required the accurate use of precision instruments such as the face-bow and the articulator, and some individualized attachments for each patient that could not be standardized.

Gnathographic instrumentation is used to help record all the interrelated factors of articulation as well as the inter-maxillary relations and the dimensions of the masticatory apparatus. <11> Through meticulous mountings and transferring of inter-maxillary records the clinician is then able to carry out a diagnosis and treatment plan for prosthetic, restorative or orthodontic needs.<30> These are the seeds that distract our profession by fogging the dentists' understanding and approach to effectively addressing and diagnosing with a bio-physiologic view of the many signs and symptoms of craniomandibular disorders.

## **The Advancement of Dental Science – *Measuring and Recording Objectively***

However, these well intentioned gnathological concepts with the more advanced mechanical occlusion system theories and perspectives overshadowed the functional occlusion theories that lingered in the historical background until the 1970's. Scientific technology was being developed linking mandibular movements and posture of the mandible with muscle function and occlusion.

Another innovator and scientific dentist, Bernard Jankelson, in 1967, was also pioneering the views of mandibular movement and function as it related to occlusion, but in another direction. Rather than taking the mechanical perspective he turned his focus to find answers within the medical arena by studying the neuro-physiology and bio-physiological effects of muscle function. It was through his collaborative studies with H.H. Dixon (1967) and E. Williamson <31> that it was concluded a low amount of energy could be used to involuntarily stimulate the muscles of mastication through the innervation of the fifth and seventh cranial nerves to facilitate jaw muscle relaxation prior to a final occlusal diagnosis and treatment.<32,33,34,35> These

bio-physiologic occlusal break throughs went beyond the traditional mechanical views of his peers. The neuromuscular and functional occlusion theories began to flourish.

In 1968, Bernard Jankelson, Father of Neuromuscular Dentistry,<70> successfully developed electronic instrumentation for the diagnosis and treatment of craniomandibular disorders enhancing and clarifying the mysteries of mandibular and temporomandibular joint positioning<65>. It allowed the clinician to visualize masticatory muscle activity and was able to coordinate these measured muscle responses to an optimal mandibular starting position to establish an occlusal scheme. Review of the mechanical occlusion theory triggered his concept that a clinical approach to occlusion should not be hypothetical or mechanical, but must have a firm theoretical and experimental basis derived from the total physiological phenomenon of the organism. The masticatory muscles, that position and connect the mandible to the skull, should be the focal point of a correct occlusion.

His physiologic approach to occlusion and techniques with scientific back-up has brought about new dimensions not only to patients suffering from craniomandibular pain which could not be cured by conventional mechanical occlusion theories<36>, but also to the dentist seeking to understand what the optimal occlusion is and how it relates to the complete stomatognathic system supported by measurable physiologic data. His concept has further been developed by many researchers and distinguished clinicians, and is now recognized as an established clinical procedure with scientific verification internationally.<37>

### **Gratitude to the Mechanical Pioneers – *Still Missing the Mark***

Dentistry owes a debt of gratitude to the great pioneers of mechanically-based gnathologic principles and theories for many of these principles have withstood scientific scrutiny and the test of time. There is more similarity between the gnathological and neuromuscular philosophies in their purist sense to treatment than dissimilarities. Who would dispute the desirability of delivering forces in the long axis of the tooth? Who would dispute that dentistry is a branch of the medical sciences and that these gnathologic concepts are for the understanding and creation of total dental health. Who would dispute the fact that there exists a finely tuned order in which teeth contact? However, the mutable definition of centric relation and the hinge axis theory throughout the gnathologic literature attest to the limitations of searching for the ideal position of intercuspation and optimal mandibular position in space using only mechanical models<38> distracting the clinician from being a doctor of the stomatognathic system. How could a mechanical model sufficiently address the physiologic aspects of the myogenous paining patient with no scientific objective validation of physiologic muscle responses before, during and after treatment?

It is difficult at this time to imagine the state of confusion in dental thinking, the cordial disagreements and sometimes not so friendly acrimony that has pervaded the dental literature as the early scientists in the field investigated jaw movements. <40> McNeil states, “Unfortunately, the definition of centric relation keeps changing in the literature.”<39, 83> The jaws have the most complex joints in the human body, and it is not surprising that anatomists and

dental scientists as far back as Leonardo da Vinci made many errors of observation as they tried to translate what they saw in cadavers to what was physiologically normal in the live subject.

### **Neuromuscular Dentistry – *Beyond the Mechanical***

Although it's been expounded that the neuromuscular dentistry principles are a radical departure from the traditional gnathological principles, it is not. Neuromuscular dentistry has simply added to the knowledge base of gnathology through the use of technologies that have evolved during the last quarter of the twentieth century. <3> B. B. McCollum once said, "If the dentist is to understand oral physiology, he must understand the actions of the joints and the muscles that operate the mandible. How the muscles and joints make the mandibular motions is the primary and, no doubt, the dominant part of oral physiology.....And it is the function of dentistry to ascertain by diagnostic means all or any involvements of the mandibular joints and muscles due to conflict of the teeth with these muscles and joints." <45> It is through these diagnostic technologies that brings new light in understanding the oral physiology of muscle function.

Neuromuscular dentistry is a comprehensive medical paradigm that:

1. Acknowledges the multifaceted MUSCULOSKELETAL OCCLUSAL SIGNS AND SYMPTOMS as they relate to the complete postural issues of the head, neck, mandibular position, muscle activity status and the temporomandibular joint position, all which in turn impact the occlusal position and relationship of the teeth. It is by these related systems that craniomandibular disorders are intimately tied. <71>
2. Utilizes the diagnosis and treatment of occlusal problems that takes into consideration the status and influences of the masticatory muscles. <46,47,48>
3. Utilizes objective and scientific diagnostic instrumentation to *measure objectively and accurately* the status of mandibular PHYSIOLOGIC REST in relation to the craniomaxillary complex as a starting position for a more efficient function of the masticatory muscle system in relationship to habitual centric occlusion. <72>
4. Recognizes a physiologic mandibular opening and closing NEUROMUSCULAR TRAJECTORY along an isotonic path for stability at a terminal contact position.
5. Recognizes and measures mandibular torque and imbalances that contribute to the afferent and efferent noxious proprioceptive stimuli during mandibular closure with freedom of entry and exit from terminal tooth contact (MICRO-OCCLUSION). <74>

Based on the foregoing premises the clinician is able to develop a diagnosis and treatment plan with objective data to make informed clinical decisions as it relates to the diagnosis, but also the *treatment* of CMD/TMD.

The philosophical premises foundational to the neuromuscular approach are based upon universally accepted medical models of health versus pathogenesis. It is a therapeutic medical paradigm that results in decompression of the jaw joints rather than compression reducing load and strain to the joint complex. It is universally agreed among medical colleagues that relaxation and decompression are elemental to all therapeutic paradigms for treatment of the musculoskeletal system.<90, 91, 92>

### **Science and Technology – *An Advancement from the Old***

Science and technology in the dental field has advanced to a higher level of understanding the masticatory system and accompanying structures through the work of Bernard Jankelson and continues to this day by scholars, academicians and clinicians. It is based on scientific instrumentation from which objective quantifiable data can be recorded to assess mandibular movements in function and an optimal physiologic rest position. Numerous scientific studies have been published in scientific and refereed journals nationally and internationally to bring to light the dynamics of mandibular function, muscle activity during resting modes and active modes. Recordings and acquired data can effectively document optimal physiologic mandibular position for each individual patient. Clear reliable evidence can now be gathered and studied to understand the true patho-physiology of mandibular movement, muscle activity, mandibular function and its relation to occlusion/ teeth and the temporomandibular joints for each individual patient needing treatment far beyond the mechanical devices that only show static relationships of mandibular movement.

The capacity to analyze gross and now fine detailed movements of the mandible takes gnathology and neuromuscular dentistry one step further into micro-occlusion. Traditional gnathology and today's present occlusion leaders have said, "The most common shortcoming in analyzing or treating occlusal relationships is failure to consider all the parts of the masticatory system. We are prone to many mistakes if our understanding of occlusion is limited to occlusal contacts alone. <49> But the evolving of computerized bio-technology has helped unlock the mysteries of occlusion, mandibular function, joint positioning and craniomandibular disorders far beyond the mechanical occlusion theories with their articulating devices.

## **Tools of Occlusal Diagnosis and Treatment**

1.SURFACE ELECTROMYOGRAPHY (SEMG) accurately measures muscles at rest and in function. <50,51,52>

2.ULTRA LOW FREQUENCY TENS (Myo-monitor/ ULF TENS) - Relaxes the muscles of mastication allowing an accurate recording of the physiologic relationship of the mandible to the cranium. <53> It also propels the mandible along a relaxed trajectory.

3.COMPUTERIZED MANDIBULAR SCANNING (Jaw Tracking)- CMS accurately measures the motion, velocity and mandibular movements in six dimensions.

4.ELECTROSONOGRAPHY (ESG) – Records, measures and locates joint sound in function.

5.RADIOGRAPHY – Panoramic, submental vertex , corrected cut tomograms or transcranials, lateral cephalogram, AP cephalogram, and lateral cervical spine films provides a tremendous amount of static subclinical information about the fossa/ condylar relationship as they relate to other cranio-mandibular cervical structures of the postural system .

Implementing these tools either individually or in combination allows the clinician to visualize and record relationships between bio-physiological and anatomical structures. These tools can also be effectively used when taking a SEMG guided bite registration. SEMG's are monitored "simultaneously" with CMS.

## **Scientific Evidence and Objectivity - *Clearing Up Historical Confusion***

Today these five diagnostic tools can clarify the misunderstandings that have plagued and clouded the majority of today's dentists. Doubt and questions can be laid aside if those that are treating patients in need are willing and bold enough to lay aside old fashion concepts and acknowledge scientific quantifiable objective data.

Although the gnathological/ traditional occlusal concepts seem convenient and easy to teach, it is plagued with short-comings in understanding the physiology of TM Joint positioning.

<54,55,41> It has been stated, "Optimal oral health is the goal of all dental treatment. Until the practitioner can visualize how each tissue looks and acts, how the complete mouth should look and function, can he begin to know whether treatment is needed or is successful when it is rendered". <49> In simple basic terms, the neuromuscular approach and concept considers the "physiologically rested" masticatory muscles as a major factor in first determining a starting point of any comprehensive treatment plan that would involve oral rehabilitation or mandibular stabilization.<3,37> Identification and diagnosis based on an optimally rested mandibular position rather than a "habitual rest" (quite a different starting point) will have a vary different clinical outcome both in the short term as well as the long term of any craniomandibular dysfunctional patients dental health.

Computerized diagnostic instrumentation supports the physiology of mandibular movement and confirms an optimal temporomandibular joint position. Assuming the habitual/ acquired bites, on most patients are a correct starting point for any dental treatment one will soon find that a pathologic occlusal position may not be the best starting point for a diagnosis and optimal treatment. Hypertension of the masticatory muscles may impact the occlusion (torques and strains on tooth structure), surrounding periodontium, and cervical head and neck region, leading to a misdiagnosis and unnecessary clinical treatment. Tomography of the joints, when indicated will clearly assist in confirming joint pathologies.<3,> The clinician should also realize that these static radiographic aids should be combined with a more dynamic evaluation of CMS, EMG and sonography to ascertain a more complete picture and assessment of the problem presented. Lacking an awareness of mandibular dynamics as they relate to the clinical findings is common, since most dentists have never acquired the training, skill and knowledge to correlate objective computerized bio-physiologic data with clinical findings.

## **Case Report –*Gnathological to Neuromuscular Treatment***

The following case presents the differences in treatment outcomes when using the gnathological concepts compared to the neuromuscular approach when rehabilitating the mouth of an Asian female, 53 years old.

### ***Chief Concern***

The patient presented with the chief concern regarding the aesthetic appearance of her existing dental work. She had no pain symptoms or complaints of pain at the time she presented for evaluation and treatment. Her medical history was uneventful and consistent with her age. Her dental history was extensive having multiple teeth replaced with multiple bridges in the upper and lower arches. {Figure 1a, 1b} She presented with a narrow V-shaped arch form resulting

in a tight end to end bite in the bicuspid and anterior region. She had a congenitally missing maxillary right cuspid that contributed to the restorative challenge of developing symmetry.



Figure 1a – Pre-existing condition and habitual occlusion before treatment



Figure 1b – Habitual Occlusion: Pre operative condition before gnathologic treatment

### ***Mechanical Gnathological Evaluation- Overlooking the Unknown***

After performing a routine dental examination and evaluation of the patient's concerns, a gnathological mind set was in play. Photographs, full mouth series of x-rays, face-bow recording were taken and dental casts were mounted on a semi-adjustable articulator in centric relation. {Figure 2} <55> Three repeatable wax bite registrations were taken to confirm reproducibility and consistency using Moyco 10X wax <56>{Figure 3} A chin point technique for recording a correct hinge axis of the jaw in centric relation was used according to gnathologic principles and techniques.<75>. A light gentle manipulated force was applied to the mandible in a repeatable hinged opening and closing manner into warm softened wax to record the maxillary to mandibular interocclusal relationship. The wax wafer was folded and then doubled again in the anterior region. The registration was taken with the patient in a semi-reclined position.

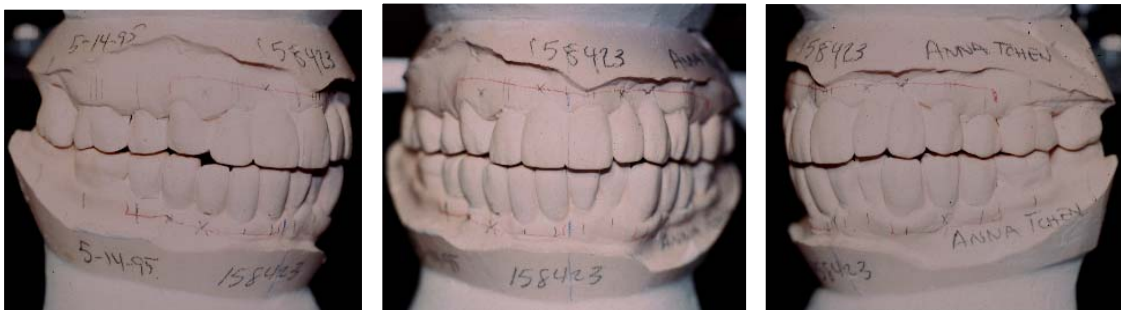


Figure 2 - Upper and lower diagnostic casts are mounted in centric relation (CR) on a semi-adjustable articulator (Whip-Mix) using a facing bow



Figure 3 - Three reproducible wax bite registrations were taken (Moyco 10X wax) in CR

A pre-treatment diagnostic wax-up of both the upper and lower arches were completed to assess restorative treatment needs and aesthetic concerns. {Figure 4} The treatment plan involved crown and bridge replacement of existing dentistry and restore any carious teeth with new restorative fillings in the upper and lower arches. {Figure 5} The existing vertical would not be altered, but maintained at the present position according to the manually derived “centric relation” (CR) bite registration. Posterior facets of wear were evaluated and confirmed that the excursive movements truly mimicked those wear patterns.



Figure 4 - Upper and lower diagnostic wax up mounted in centric relation (CR) on a semi-adjustable articulator (Whip-Mix).



Figure 5 – Existing condition after removal of upper and lower bridges

All restorations were fabricated and delivered. All restorative treatment was completed and a detailed gnathological occlusal correction/ equilibration was performed per cusp fossa principles of occlusion in CR. Accu-film <57> indicator paper was used to record any premature contacts and were removed resulting in a tripodized occlusion. Cuspid guidance and any interfering inclines were checked and removed. Working interferences in both lateral excursions were also corrected. Follow up after treatment casts were taken and then remounted on a semi-adjustable articulator in CR to confirm accuracy of the patient's occlusion using 0.001 Mylar shimstock <58>. Shim held in all areas of tooth contact. {Figure 6}



Figure 6 – Gnathologic Occlusion: Centric relation position after restorative treatment

#### ***Craniomandibular/ Musculoskeletal Occlusal Signs and Symptoms Awakening***

One year later on a routine follow up hygiene visit, the patient complained to the hygienist that she was experiencing ringing in the ears bilaterally. She also indicated that due to these developing symptoms it caused her to seek medical consultation. She went to see an ENT specialist who confirmed no ear infection or pathology present. She also complained of a lower right second molar toothache. { Figure 7} She saw two previous dentists under an emergency basis for the pain in her lower right second molar. They recommended molar extraction due to pulpitis and decay on the distal. On a subsequent office visit, recurrent decay was removed and a restorative filling was placed. The toothache was resolved on the same visit by adjusting the occlusion and removing interfering inclines in lateral excursions.



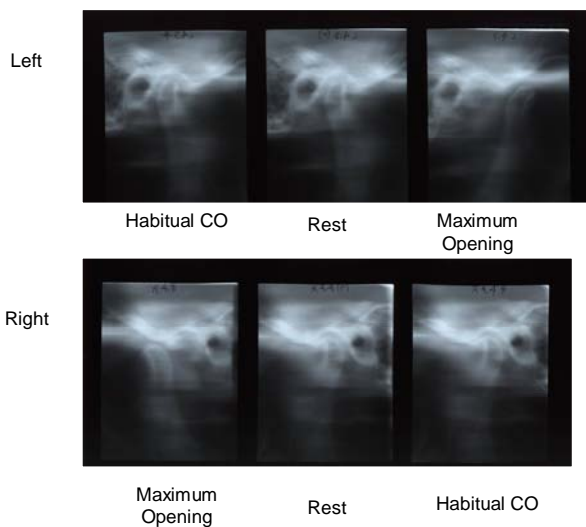
Figure 7 – Panoramic: Existing condition before gnathologic treatment

A half a year later the patient complained of severe headaches with difficulty chewing. Severe head pain on both the left and right sides was present. She also complained of numbness and tingling in her hands and fingers. Restrictions in head rotation, hyperextension and flexion were also noted. Craniomandibular dysfunction was diagnosed. Additional symptoms were disclosed

which included stiff neck, shoulder pain, numerous facial muscles were tender on palpation, along with teeth sensitivity. These symptoms are commonly associated with craniomandibular disorders .<19, 20>

It was during this time that the author was evolving into the neuromuscular concepts and recommended the patient have a full series of head and neck radiographs including submental vertex, correct cut tomograms, AP tomograms, lateral cervical spine film and a panoramic film. Corrected cut tomograms were taken in habitual occlusion, rest and maximum open position. {Figure 8a and Figure 8b} A computerized diagnostic work-up was also completed to evaluate any craniomandibular relationships using SEMG evaluation followed by application of ULF TENS <57>. Ultra low frequency TENS is used to establish a neuromuscular position in space. <59, 60, 61> Resting muscle activity was recorded with EMG before and after TENS. When optimal resting low EMGs levels were established, a K6-I kinesiograph tracing was used to track and verify a stable repeatable baseline with an intermittent sharp even pulse.

**Figure 8a-** Corrected cut tomograms: Before treatment - Habitual occlusion, rest and maximum opening. Osteodegenerative changes are present on both left and right condyles with sclerosis and beaking. Note hyperplastic changes of the condylar neck region. Condyles posteriorized and superiorized in centric occlusion. Condyles hyperextends beyond height of articular eminence on maximum opening.



**Figure 8b-** Lateral Cervical Spine

Review of the CMS recordings demonstrated the gnathologically CR=CO occlusion was 3.0 mm posterior and 4.3 mm superior from physiologic rest position. {Figure 10, 11} Habitual rest before ultra low frequency TENS indicated a 0.4 mm vertical freeway space. {Figure 9} EMG data indicated hyperactive masseter, posterior temporalis and digastric muscle activity bilaterally (less than 2.0 mV is the norm.). {Figure 13} Functional EMG tests indicated muscle imbalances

when the patient was instructed to clench in the restored CR position, with lower EMG readings of both left and right anterior temporalis than the masseter muscles. <62> EMG clench test indicated an increase in functional EMGs when the vertical dimension was altered by placing cotton rolls as the control. <63> {Figure 15} Improved functional muscle recruitment was recorded with a removable lower orthosis placed at the neuromuscular position. {Figure 16} Restricted lateral mandibular movements both left and right sides were recorded, 5.8 mm to the right and 8.5 mm to the left. Range of motion was restricted with pain on maximum vertical opening of 32 mm (Normal is 48-55 mm). { Figure 20} Opening velocity of the mandible was slow and irregular. Opening and closing movements documented bradykinesia and dyskinesia. Deviation to the right was present on mandibular opening. {Figure 18} After muscle relaxation therapy using low frequency TENS for 60 minutes, electromyographic (EMG) recordings documented a lowering of EMG activity compared to pre-pulsing on the ULFTENS unit.

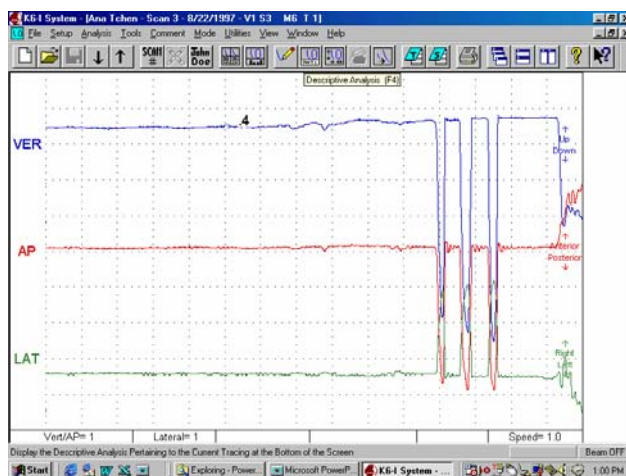
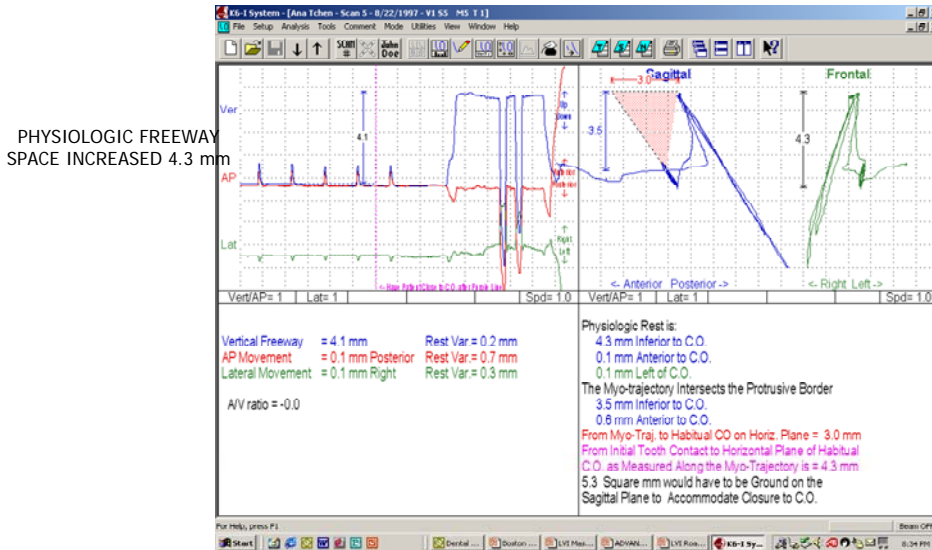


Figure 9 – Computerized mandibular scan 3 (XY sweep) showing deficient vertical (0.4 mm habitual freeway space) before myomonitor TENS.

**Figure 10** – Computerized mandibular scan 4/5 (XY sweep, sagittal and frontal views) showing increased physiologic freeway space of 4.3 mm from habitual CO after myomonitor TENS. Sharp even pulse indicative of muscle relaxation and minimal to no muscle splinting during Myomonitor TENS pulse.



**Figure 11** – Note neuromuscular trajectory is anterior of habitual trajectory and inferior and slightly anterior to the previous manually manipulated (centric relation) position.

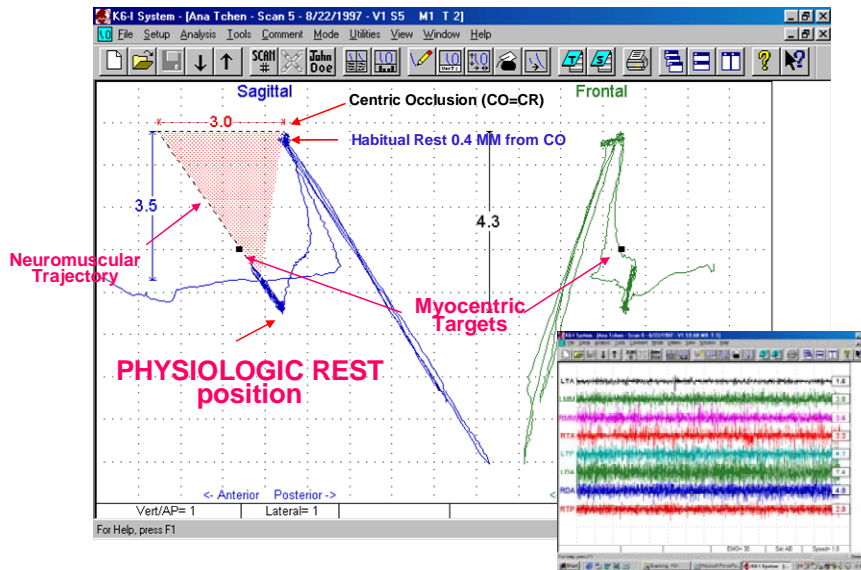


Figure 13 – Resting surface electromyography before treatment showing hyperactive muscles activity (Scan 9).

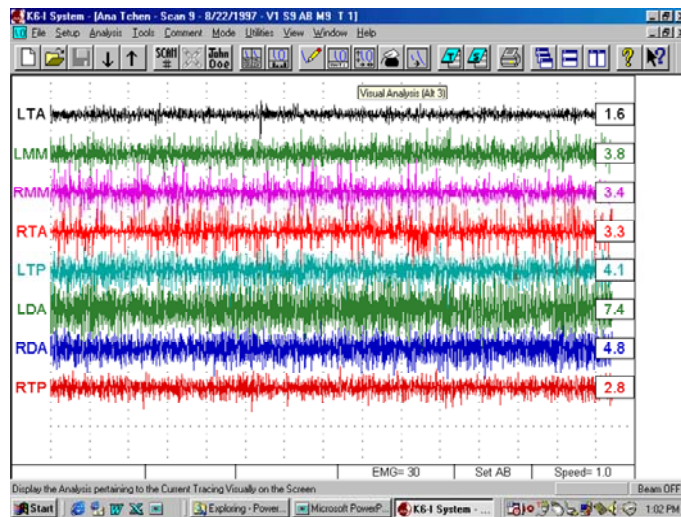


Figure 15 – Scan 11: Before treatment functional EMGs indicating unbalanced muscle firing (gnathologic/CR occlusion) between the left and right temporalis anterior and masseter muscle groups.

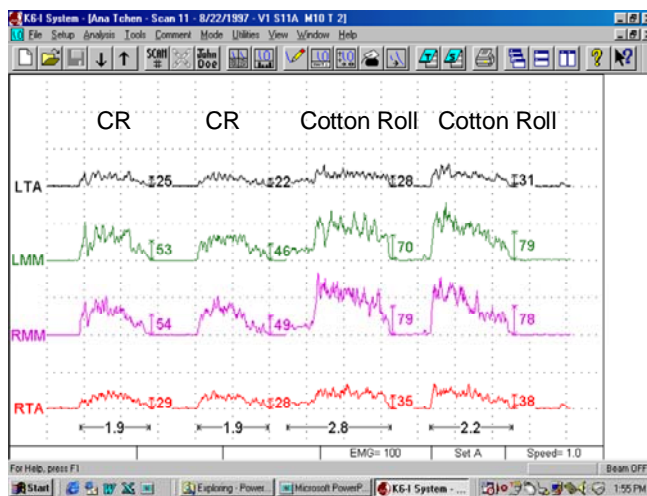


Figure 16 – Scan 11 (Functional clench test) indicating a lower EMG muscle activity at the gnathologic position compared to an increased muscle recruitment at a physiologic position.

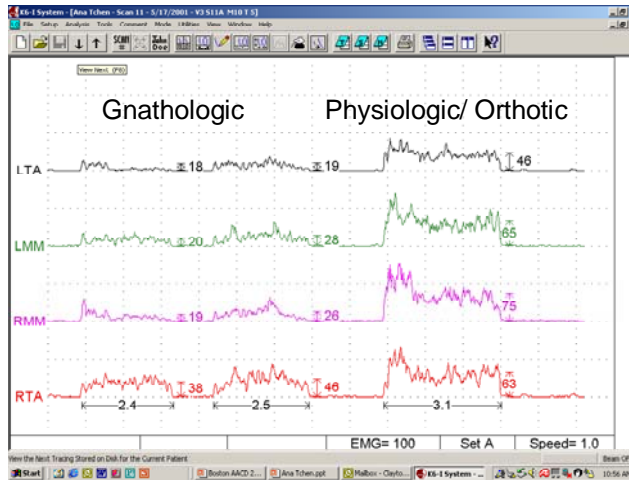


Figure 17 – Scan 11: After neuromuscular orthotic treatment. Functional EMGs indicating balanced muscle firing (physiologic occlusion) 3.5 years post operative.

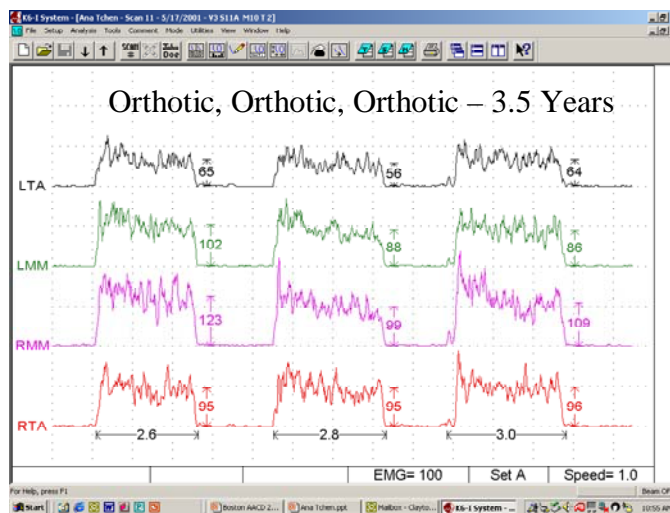


Figure 18 – Existing gnathologic/ centric relation scan 2 tracings shows bradykinesia and dyskenetic mandibular movements during open and closing mandibular movements with right deviations on the frontal tracing.

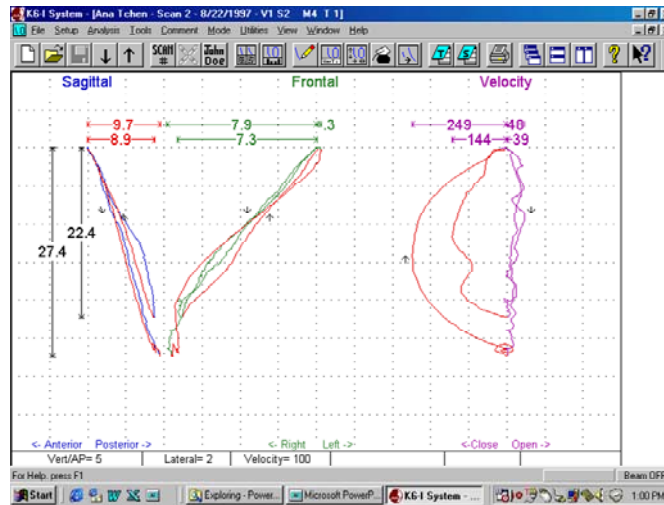
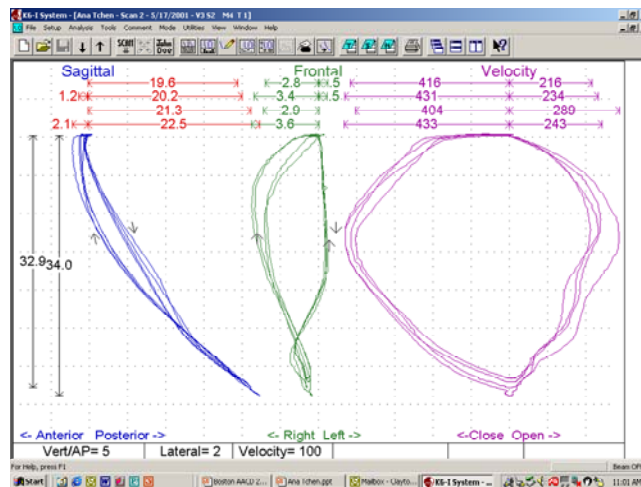


Figure 19 – Physiologic occlusion: Five years post operative scan 2 tracing indicates improved and occlusally stable neuromuscular position with lower removable orthotic.



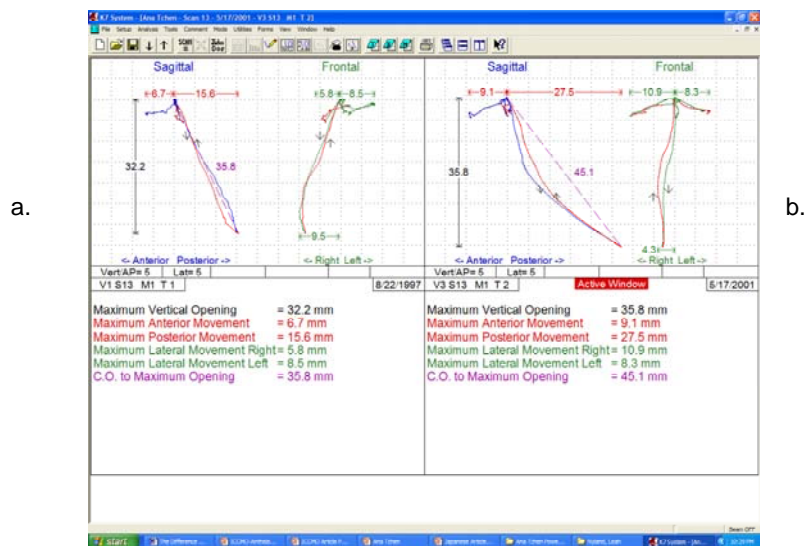


Figure 20 -CMS recordings of mandibular range of motion indicates improved function (Scan 13) . a) Restricted range of motion with gnathologic/centric relation treatment. b) Increased range of motion after neuromuscular orthotic treatment.

Tomographic evaluation indicated both left and right condyles were posterior and superior in the glenoid fossa due to the gnathologic position. On maximum opening, subluxation of the condyles past the inferior border of the articular eminence was observed. Evidence of osteodegenerative changes were present on the anterior surface of both left and right condyles with evidence of sclerosis on the posterior surface of both the left and right articular eminences. The lateral cervical spine film indicated a lack of lordotic curvature in the cervical/ neck region. {Figure 8b}

A lower acrylic orthotic with occlusal morphology was fabricated to the above parameters in the relaxed neuromuscular position. Jaw tracking recordings with simultaneous EMG and TENS (Scan 4/5) were used to record physiologic rest, determine a correct neuromuscular trajectory and locate the physiologic rest position. {Figure 11,12a, b, c} A myocentric <64> target with freeway space of 1.5 mm above physiologic rest before taking a bite registration was identified and located, based on simultaneous real time EMG data and mandibular jaw tracking in both the frontal and sagittal planes. <11>.

**Figure 12a** - Myocentric Bite registration taken with computerized mandibular scanning (CMS), ultra low frequency TENS and simultaneous EMG monitoring

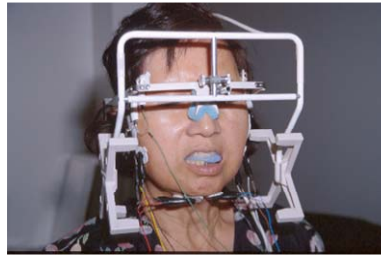


Figure 12b- Anatomical lower orthotic

**Figure 12c-** Casts mounted with the Myocentric bite registration



Post operative CMS and EMG data was recorded 3.5 years and 5 years later indicating low EMG recordings at the neuromuscular mandibular position compared to the higher resting EMG recordings of the previous centric relation position. {Figure 14} The after TENS CMS data indicates that the neuromuscular trajectory equals the habitual trajectory on both the sagittal and frontal tracings. {Figure 22, 23} Coronoplasty principles were followed to adjust and deliver the lower neuromuscular orthotic appliance<3> implementing measured data (Scan 12) to validate minimal mandibular torque during voluntary mandibular closure to an accurate predetermined terminal tooth contact position. {Figure 24} A functional chewing cycle (Scan 8) was used to confirm muscle balance and preciseness of the established centric occlusal contact along an isotonic path of closure during un-posed function. It has been five years and the patient remains stable, happy and pain free. {Figure 25} A final restorative phase of treatment has been proven stable and will be completed at the neuromuscularly proven position. {Figure 26}

Figure 14 - Lower resting EMG recordings post operatively after wearing orthotic 3.5 years after 1 hour Myomonitor TENS (Scan 10).

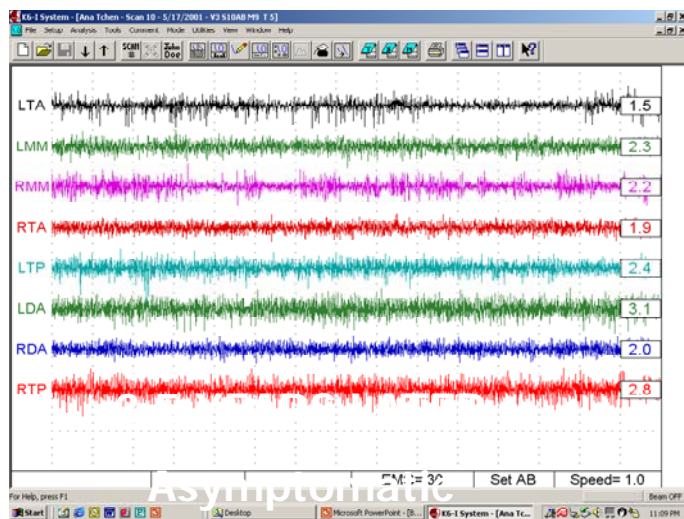


Figure 22 – Computerized mandibular scan (sagittal and frontal views) showing, (a) physiologic rest position and neuromuscular trajectory after gnathologic/ CR restorative treatment and (b) after neuromuscular orthotic/ TMD treatment.

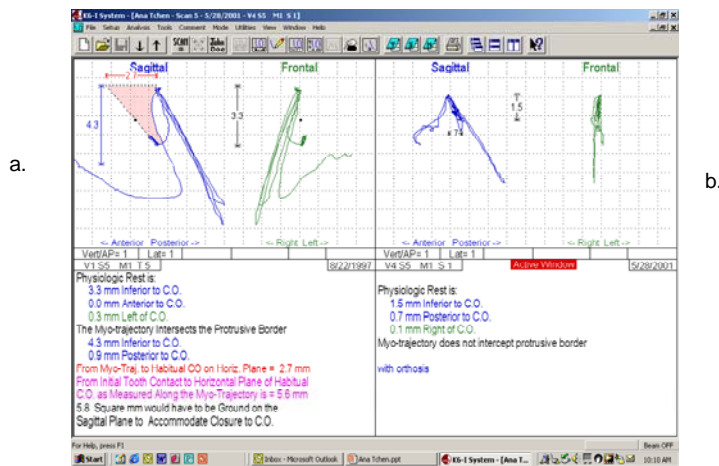


Figure 23 – NM position 5 years stable

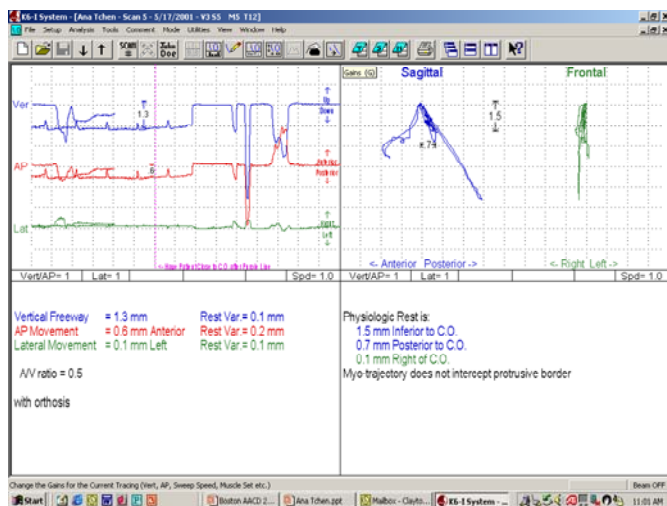


Figure 24 - Scan 12: Functional isometric EMG display of mandibular torque before final orthosis adjustment indicating premature tooth contact on anterior bicuspid cuspid to cuspid region (homologous pairs).

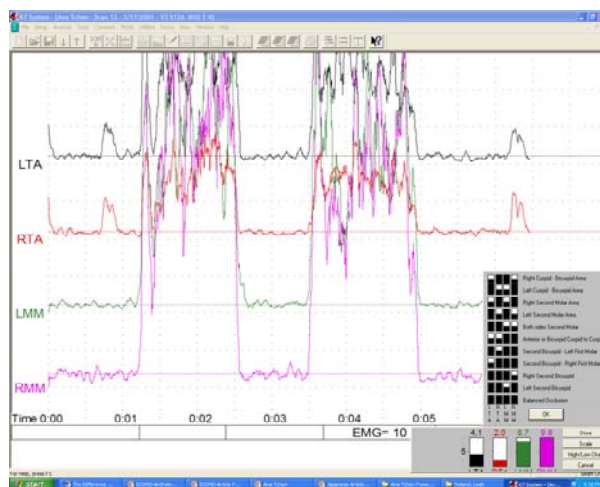


Figure 25 - Chewing cycles (Scan 8): (a) Before final orthotic adjustment chewing cycles indicate guarded occlusion with non-repeatable centric terminal contact. (b). After orthotic adjustment chew cycle indicates precise occlusion free of interferences during exit and entry into a terminal contact position. Lateral excursive border movements are traced.

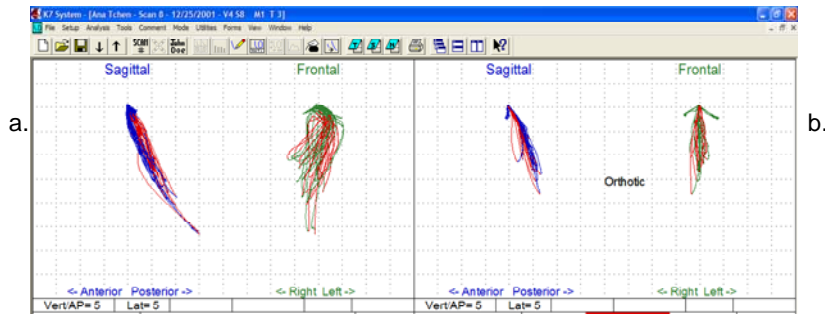


Figure 26 - Patient asymptomatic after years of craniomandibular dysfunction and TMD pain. Five years orthotic stabilization, ready for restorative treatment at neuromuscular position.



## Discussion

The preceding clinical case demonstrates how gnathological teachings of occlusion may overlook the bio-physiological aspects of mandibular posture and joint position. The static model of gnathological principles of occlusion, using face-bows and articulators, along with

manual manipulative techniques to establish a maxillary to mandibular position fails to address the bio-physiologic aspects of mandibular and condylar posture as they relate to the masticatory muscles and dental occlusion. Manual manipulation techniques in centric relation in a repeatable and consistent manner fails to acknowledge that muscle physiology of the head, neck and the masticatory system is sensitive to anatomical imbalances and plays a major role in mandibular posture and occlusal stability for the patients medical and dental health. The neuromuscular approach adds another dimension to understand the interrelatedness of the craniomandibular system. By using computerized diagnostic and treatment technology the clinician is now able to visualize another dynamic dimension of muscle activity and mandibular positioning synchronously, guiding the patient to an optimal myocentric position in space without manual intervention. Muscle relaxation is established via ULF TENS to capture an optimal myocentric position in six dimensions to the cranium.

A precise two stage occlusal refinement procedure is followed by using the Myomonitor and simultaneous CMS and EMG to assure synchronous functional cusp tip contact on involuntary and voluntary closure. The second stage is the isometric functional micro-occlusal refinement to assure that freedom of entry and exit occurs with no deflective contacts during mastication. Functional cusp tips and marginal ridges are preserved removing unwanted interfering inclines that would trigger a pathologic muscle response.

Although mandibular border movements have been strongly emphasized in the traditional mechanical theory of gnathology as to establishing parameters of cusp fossa occlusion and disclusion, the neuromuscular concepts acknowledges the importance of muscle rest and establishes a precise physiologic myocentric occlusion free of manual intervention which meets all the requirements of masticatory function and rest as its focus. Protrusive, retrusive and lateral bordered movements along with cuspid disclusion and anterior protrusive protective disclusion does exist in the neuromuscular scheme of occlusion without mechanical intervention. Dental health is the ultimate goal with normalized mandibular function where the patient is pain free, musculoskeletally balanced, dental aesthetically pleasing and occlusally stable.

Computerized technology that scientifically measures physiologic responses of the masticatory muscles enhances ones perspective of where to establish an occlusion during the diagnostic phase. More importantly, objective measurable data can be practically implemented during the clinical treatment finishing phase to validate when a mode of treatment is complete and successful. Harmony of the temporomandibular joints and muscles of mastication to a physiologic occlusion plays a dynamic role in effective treatment of the craniomandibular symptomatic patient.

## **Conclusion**

All true gnathologists when understanding the complete craniomandibular/ neurovasomuscular/ cervical components as well as the occlusal concepts that impact the stomatognathic system are truly striving towards the neuromuscular approach. If all the dentists that practice the so called gnathological concepts as taught by the great pioneering doctors, would perpetuate these teachings to their highest level, they would soon realize that the neuromuscular approach, as confirmed by scientific instrumentation, addresses the missing link to understanding all border movements of the mandible, the determinants of occlusion and the physiology between occlusion

(teeth), the supportive and functioning muscles, and the optimal condylar position within the glenoid fossa.

The author for years emphasized that gnathological treatment endeavors to relate the teeth properly to each other in such a way that they will have a non interfering relation to the jaw motions and joints. He later realized through clinical practice that even though the concept and philosophy sounded well and good, it fell short of physiologic science and objective ideals purported when treating his patients daily in clinical practice, especially in those more challenging TMD cases.

Although great strides and progress have been made from the classical gnathology concepts to the more recent neuromuscular concepts, future investigations and research should include:

- Posterior jaw tracking for a true 6 dimensional mandibular evaluation.
- Grid surface SEMG and first tooth contact correlations.
- SEMG signal differentiation muscles such as medial and lateral pterygoid.
- Clinical applicability of skin mechanoreceptive, thermoreceptive, and nociceptive measurements. (Neurophysiology, EEG).
- Muscle nerve sympathetic activity in relationship to vascular baroreflex and skin nerve sympathetic activity in thermoregulatory functions.
- Potential of SEMG electrode grids in evaluating the level of muscle unit synchronization.

The neuromuscular approach is certainly welcomed especially in the realm of restorative dentistry and musculoskeletal/ TMD/ craniomandibular problems. For many of us who have been recipients of out moded traditional teachings of gnathology and seeing the short comings of the standard dental teachings in dentistry today, it is refreshing and inspiring to understand how the stomatognathic systems truly functions in light of supporting scientific instrumentation that can record and verify the observations and symptoms presented by our patients.

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