

Physiological State of Occlusal Orthotics and the Diagnosis of Myogenous Orofacial Pain in Reducing TMD Headaches and other Symptoms

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Abstract:

Treatment of common myogenic oriented orofacial pain in dentistry using occlusal orthotics has been shown to be effective in reducing masticatory muscle discomfort and dysfunction. Dental literature recognizes that occlusal interferences diminishes normal musculoskeletal movement and are harmful. Diagnosis of these problems using precise technology can aid the dentist in correcting these structural problems confirmed with objective occlusal analysis. Dentists have the responsibility in assessing and diagnosing the structural component of each patient's musculoskeletal occlusal system. Precise occlusal adjustments and management of the orthosis implemented in restorative dentistry, orthodontics, and orthognathic surgery can assist in reducing temporomandibular dysfunction (TMD) headaches pain and dysfunction. Understanding neuromuscular stress reduction protocols are key in orthotic appliance design and occlusal management in order to help the biomechanical efficiency, chewing ability and, reduction in signs and symptoms of TMD patient treatment. Computerized digital occlusal analysis provides objective data of occlusal contacts and muscle force to accurately assess diagnosis and treatment, as monitored with computerized jaw tracking and electromyography (EMG). The rationale and requirements for proper orthosis fabrication based on a verified therapeutic occlusion are presented, in this paper with the introduction of a new term to the literature: Gneuromuscular (GNM) dentistry. This article presents a new type of appliance based on electro-dynamic physiologic parameters in the diagnosis and treatment of myogenous pain related to adverse occlusal function.

Key words: occlusal orthotics, myofascial pain, computerized occlusal analysis, transcutaneous neural stimulation (TENS), electromyography, jaw tracking, gneuromuscular, GNM

“Orthosis (a dictionary term) is defined as an orthopedic appliance or apparatus used to support, align, prevent or correct deformities or to improve the function of movable parts of the body”.¹ It has become common to refer to this device as an orthotic. An orthosis is a custom-fabricated or custom-fitted device or support designed to align, correct, treat muscles, joints or skeletal parts which are weak, ineffective to prevent neuromuscular or musculoskeletal dysfunction, disease, injury, or deformity.¹⁸ An orthosis fits over the teeth to realign the jaw and associated structures to a functional and orthopedic position. An orthosis when properly adjusted should eliminate masticatory dysfunctions and enhance functional health and stability.

A splint is defined as “a rigid or flexible appliance for the fixation of displaced or movable parts”.¹ “Splints” are technically used to protect the teeth and or immobilize jaw. It may be custom formed to fit over the teeth, but are not intended to *precisely* re-position one's jaw relationship.

Introduction

Research has shown that occlusal interferences affect muscle, temporomandibular joint coordination, cognitive function and subcortical brain centers.²⁻⁵ Literature shows adverse occlusal forces are not beneficial to the patient and should be corrected as part of optimal care.^{6, 7} Relaxing musculature prior to performing any occlusal equilibration or changes made using an occlusal appliance

must follow the general laws of homeostasis if a reduction of TMD symptoms are desired. Muscle tension is undesirable in the postural state. Relaxation is desirable and a recognized therapeutic postural state.⁸⁻¹⁸

Non-dental orofacial pain is a significant presenting problem to the clinical dentist since it is commonly pain. Students of dentistry recognize that myogenous orofacial pain can be perplexing. Myogenous orofacial pain is

prevalent, both in acute and chronic states, and therefore can be a remarkable clinical challenge.²²⁻²⁷ Relief of pain is a gold standard in TMD oral healthcare, however the etiology of myogenous orofacial pain can appear ambiguous and therefore the appropriate treatment can be unclear. Without a definitive diagnosis there can be no definitive treatment. The peer-reviewed literature is not unified as to the etiology of myogenous pain; to quote Kidder and Solow, “*The dental literature on occlusion as a causative or contributory factor in myogenous orofacial pain is extensive and contradictory. Proponents relate occlusal interferences to masticatory muscle incoordination, suboptimal muscle function, masticatory muscle hyperactivity, and pain. Opponents attribute the etiology of myogenous pain to psychological maladaptation to stress, or neurologic problems such as central sensitization, or somatization disorders. These opponents recommend symptomatic relief -- without any structural change -- via physical therapy, drugs, psychotherapy, self-management, or oral surgery as a placebo treatment.*”²⁸ The opposing and unclear dental literature further challenges the clinical dentist who will be without definitive guidance on a structural correction of the occlusion or a palliative approach.

While central sensitization and psychological problems may have some contributions in certain cases of orofacial pain, this debate over etiology obscures the fact that it is the dentist’s principle duty to assess the state of structural and functional health to the patient’s condition. A comprehensive examination of the stomatognathic system is the standard of care as stated by the American Dental Association, Academy of General Dentistry, American Academy of Craniofacial Pain, and others; ^{22, 29-34} this should include occlusal and joint analysis, range of motion, quality of motion and muscle health and function in addition to a psychosocial cursory evaluation to assess the role of the stomatognathic system whether it is in health or dysfunctional pain. Dental appliances to correct the mal relationships of dental occlusion are widely accepted as therapeutic. They are a conservative non-invasive first step in the diagnosis and treatment of occlusal therapy.³⁵ Not all intra oral appliances are the same or equivalent in their effectiveness. This article presents a new type of appliance based on electro-dynamic physiologic parameters (to be defined later in this paper) in the diagnosis and treatment of myogenous pain related to adverse occlusal function.

The Dental Literature

Historically, the literature on the relationship between occlusion and myogenous orofacial pain has been divergent and confusing to many. Proponents of a bio-psychosocial model of myogenous orofacial pain view the occlusion as having little to no causality.^{36, 37} A trend is seen among these studies of the bio-psychosocial model of not specifying the actual occlusion in terms of mandibular positioning in a healthy normalized six-dimensional space (vertical, antero-posterior, frontal/lateral, pitch, yaw and roll) contact force, timing of occlusal contact, gnathological functioning, range and quality of motion, joint health as they relate to muscle health and function, and abnormal airway breathing. Conversely, the literature is also heavily supplied with the position of causality between the occlusion and myogenous orofacial pain. Of the extensive supportive literature of note are the works of Kirveskari, et. al. demonstrating the link between occlusion and myogenous pain of the entire head and neck region³⁸⁻⁴⁰, Cooper’s landmark papers on the efficacy of neuromuscular orthosis for reduction of symptoms and classic study showing the resolution of 1182 TMD patients ^{41, 42}, Cooper and Kleinberg’s reporting the reduction effects of 313 TMD symptomatic patients when establishing a temporomandibular physiological state using neuromuscular orthosis treatment⁴³ and Yamashita’s stunning 30 year follow up on a neuromuscular treatment of a TMD case showing the stability of occlusal health ⁴⁴. The supportive literature continues to expand with supportive evidence to current date showing their effectiveness in treating orofacial pain.^{35, 38, 43, 45} The authors also submit as self-evident, the common clinical patients in distress experience of every ‘wet-fingered’ dentist (although often passed over as “anecdotal evidence”), that occlusal interferences cause distressing nociceptive input contributing to pain and dysfunction of the head and neck of TMD patients. Literature has clearly stated the confusing states of viewpoints between the occlusal myogenous orofacial pain connection and those opposing such in a recent paper.^{28, 29, 37, 42, 43, 46, 47}

Overall, it is important to note that research that does not objectively measure locational *healthy* parameters relating the mandible to the maxillary arch, relating the quality of occlusal contact balance to physiologic (healthy) vertical dimensions and relating *healthy muscle recruitment* patterns to

a healthy neuromuscular mandibular closure pattern cannot account for nor rule out, its weight of causality toward treatment effectiveness.^{16, 17, 43, 48-53} Research has indicated that healthy vs. unhealthy subjects exhibit occlusal contact time and force patterns relating to a causal role of dysfunction and impairment.^{49-52, 54-57} It is important to recognize that ignoring these relationships of occlusion to myogenous orofacial pain is not an excuse to disprove that this relationship does exist (Figure 1a and 1b).

Appliance Design Based on Electro-dynamic Physiology and Functional Parameters

There continues to be an unresolved debate on the etiology of myogenic orofacial pain. Currently, there is no agreement among healthcare providers as to the causes or the best course of treatment of myogenous orofacial pain.²⁸ Resolution of these problems with precise occlusal correction indicates that dental occlusion is a causative or contributory factor in dysfunction and myogenous orofacial pain.^{14, 58-68} Some studies in the literature on myogenous orofacial pain do not account for occlusal contact time, location, intensity or muscle activity or mandibular kinematics, both in pre-study condition or in corrected occlusion.^{29-31, 36, 37, 46, 69-78} Not all orthotic designs are equally effective: anatomical design should not introduce nociceptive interferences. Dental orthotics should follow the biological law of form following physiologic function of the masticatory system for optimal resolution and sustained health. Diagnostic casts mounted in a MIP (maximum intercuspal position/habitual occlusal position) or mounted to a position referenced from the physiologic rest position are reference relationships commonly used for objective analysis. Physiologic registration is defined in this paper as an inter-occlusal recording established with the mandible in a physiologic rested position raised through the inter-occlusal space along an isotonic mandibular trajectory that is objectively measured and quantified.^{10, 101} Polyvinyl or a firm setting bite registration material is used. It is based on sound principles of gnathology and bio-physiology.⁷⁹⁻⁹⁷

Introduction to Gneuromuscular (GNM)

Gneuromuscular represents a combined approach that acknowledges both the principles of jaw movement and function (gnathology, the study of jaw, gk.) and the bio-physiology of the masticatory system (neuromuscular, the

study of the associated entities of the trigeminal (V) and facial (VII) system and muscles). GNM focuses on the precise and accurate application of these two foundational occlusal concepts together and not neuromuscular occlusal concepts alone.

The gnathologic occlusal teaching has been a dominating concept within most dental school curriculum over the past 100+ years. From the early developments of the dental articulator by Bonwill (1858), to Gysi's denture articulations (1905) and his challenge regarding the emphasis of gnathic concepts on mandibular movements, the principles of gnathology have withstood years of scrutiny and are supported in the literature: condyles seated on TMJ disc^{98, 99} multiple, bilateral posterior tooth contact^{82, 83} and proper anterior guidance.⁵²⁻⁶¹ These proven concepts of occlusion have helped establish the foundation upon which neuromuscular bio-physiology has been able to emerge its scientific standing in the dynamic study of the complete "gneuromuscular" functional system.^{10, 16-17, 29, 45, 62-65, 68}

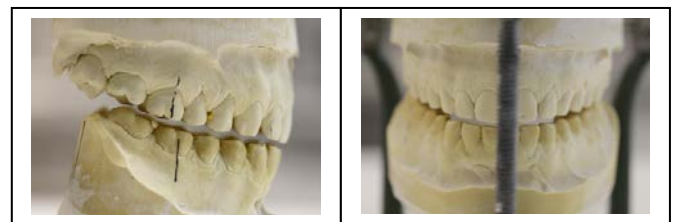


Figure 1a and 1b: The physiologic maxillary to mandibular relationship is established from a rested muscle position using low frequency J5 Dental TENS combined with computerized K7 jaw tracking as aid to identify the arc closure and 6-dimensional relationship opening objectively -[with no manual manipulation. Vertical opening generates physiologic reproducible patterns consistent with Gneuromuscular (GNM) principles.

Neuromuscular occlusal theory is the understanding from an "objective measured" perspective of dental occlusion as it relates to the activity of masticatory muscles which are controlled by neural integration of the central and peripheral nervous systems. It was not until computerized electro-diagnostic technology developed to a level where it was possible to measure muscle activity, jaw movement and occlusal contact quality in real time that this theory could be realized in applied dentistry with objectively quantifiable measured testing.

The starting point of neuromuscular occlusion is the “physiological rest position” which is a mandibular position in which the muscles are simultaneously at their resting length and in balanced tonus with one another.¹⁰ From the physiological rest position, an isotonic closing trajectory (myo-centric) is identified, which is the arc of closure through the freeway space with muscles *at minimal electrical activity*.^{10, 100} An isotonic mandibular closure pattern can be objectively measured and monitored by mandibular jaw tracking instrumentation in real time (Figure 2, 3a and 3b) using with low frequency dental TENS; this allows the clinician to find a repeatable (isotonic) and reproducibly (involuntary) measured closing trajectory which is commonly overlooked and ignored in dentistry. Myo-centric is the terminal contacting point along the closing trajectory at which occlusal contact occurs. This isotonic closing path of the mandible when it moves up from physiological rest position to a myo-centric allows maximum function with minimal energy expenditure.^{10, 100, 101}

The synergistic blending of these two concepts, gnathology (mechanical) and neuromuscular (functional) is the emergent theory of GNM. Stated in its purest form, gneuromuscular is gnathology at the neuromuscular position.^{102, 103}

Occlusal Analysis

As with any medical procedure, a diagnosis should be established before treatment begins.¹⁰⁴ Proper diagnosis of orofacial pain requires a comprehensive medical and dental history, evaluation of emotional stressors, assessing pharmacological (prescription drug/medication) status, and nutritional evaluation in addition to the occlusal analysis.²² The goal of the occlusal analysis is to detect any dental, skeletal, muscle, cervical neck or posture disharmony of the condyle/disc assembly (joint harmony).¹⁰⁵⁻¹⁰⁷ It is inadequate to evaluate the dental occlusal relationship solely in MIP using stone models, because health and quality of the functional activity of the masticatory muscles and TM joints cannot be accounted independently during an examination. Articulating stone modes in MIP do not provide dynamic insight of skeletal torque, postural dysfunction or quality of arc of closure.¹⁰⁸⁻¹¹⁴

Some of the more prominent clinical signs of occlusal dysfunction are abnormal occlusal wear, abfractions,

dental crowding, loss of teeth, narrow dental arches, change in condylar shape, TMJ grating noises on opening and closing, canted maxilla, facial asymmetries, head posture, abnormal neck alignment and abnormal tongue posture. The clinical symptoms of non-ideal occlusal relationship include impaired range of motion, quality of motion, joint sounds (e.g., TMJ clicks, grating sounds and pops), facial pain, muscle pain, tension headaches, failing restorations, tooth mobility and bone loss to name a few.¹¹⁵ Most essential in any analysis of the dental occlusion is to find the proper physiologic rest position (homeostasis, *physiologic neutral*) which is a reasonable, logical and scientific starting reference point for diagnosis for occlusal treatment.¹¹⁶



Figure 2
 Figure 2: K7 Kinesograph: Computerized mandibular scanning (CMS – jaw tracking) and electromyography (EMG) (Myotronics-Noromed, Inc, Kent, WA) is used to measure and monitor jaw positioning and muscle activity objectively.

Dynamic Functional Occlusal Assessment: Mandibular Positioning

Before altering or modifying any occlusal scheme of a patient who exhibits TMD and orofacial symptoms it is imperative that the clinician performs a comprehensive assessment of the mandible relative to the maxillary arch relationship to determine its “physiologic” location.

Understanding and knowing the significance of a patient’s maxillo-mandibular interocclusal relationship is key to optimal occlusal management since this unrecognized and often overlooked entity (not seen radiographically) is in direct association with the condyle/disc and glenoid fossae and surrounding masticatory muscle system. The

intercuspal (IP) position is commonly assumed to be the functional and physiologic position for an individual but objective dynamic testing has shown that **82.1%** of a 313

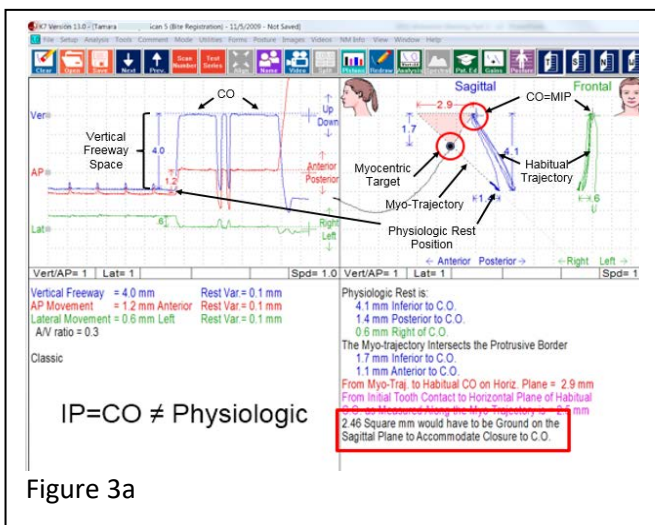


Figure 3a: CMS Scan 4/5 recording before orthotic (habitual trajectory not coincident with the myo-trajectory).

TMD test population had over-closures (excess vertical freeway space), **53.9%** had lateral displacements, **71.8%** had posterior mandibular displacements, **84.1%** showed mandibular closure patterns not coincident with the neuromuscular trajectory.¹³⁹ Additionally, literature

indicates **70-89%** is the prevalence of TM degenerative disease as indicated in studies by Haskin (1995), Emshoff (2003), Tasaki (1996), Katzberg, et al (1996).^{43, 117-119} These findings and reports are only a small sampling of the confirming evidence that has been reported in the literature, yet go unrecognized by the general dental community.

Computerized mandibular scanning (CMS) allows the clinician to precisely and accurately identify a patient's mandibular position relative to the habitual occlusion prior to any occlusal treatment. These diagnostic measurements aid the clinician to determine whether the voluntary mandibular closing path is coincident with its involuntarily isotonic neuromuscular closing path. Physiologic laws of homeostasis and mandibular function indicate that a mandibular closing path should not have any deviations (slides) sagittally or laterally when "...all the masticatory muscles including all antagonistic muscle groups such as elevators and depressors are in the state of *minimal electrical activity* necessary to maintain postural rest" (The Glossary of Prosthodontic Terms, GPT-1).¹²⁰ A

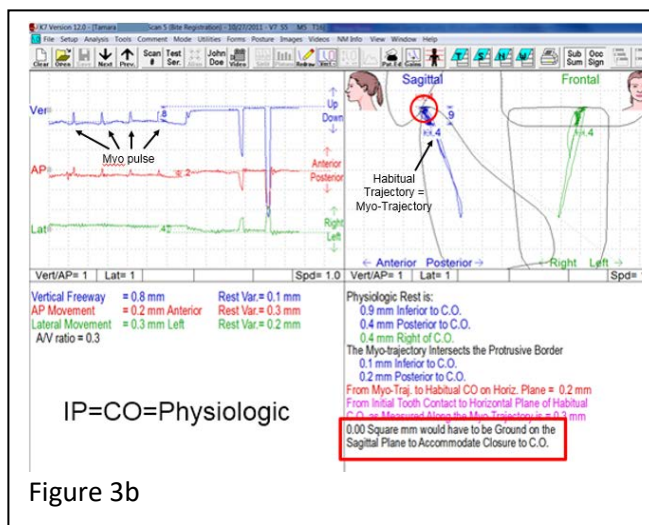


Figure 3b

Figure 3b: CMS Scan 4/5 recording after orthotic treatment (habitual trajectory is coincident with the myo-trajectory). Computerized mandibular scanning using Myotronics K7 kineseograph displays mandibular functional opening and closing patterns (sagittal and frontal/lateral) and physiologic positioning using *synchronous* low frequency J5 Dental TENS relative to the (centric occlusion/intercuspal position (CO/IP) terminal contact position over time (shown in right side of each of the two windowed recordings). Left windows of each of these recordings displays mandibular positioning (vertical, antero-posterior and frontal/lateral) at physiologic rest positioning over time relative to CO/IP while using dental TENS (relaxed/involuntary) and voluntary closure to CO patterns.

Habitual trajectory is coincident with the myo-trajectory. Computerized mandibular scanning using Myotronics K7 kineseograph displays mandibular functional opening and closing patterns (sagittal and frontal/lateral) and physiologic positioning using *synchronous* low frequency J5 Dental TENS relative to the (centric occlusion/intercuspal position (CO/IP) terminal contact position over time (shown in right side of each of the two windowed recordings). Left windows of each of these recordings displays mandibular positioning (vertical, antero-posterior and frontal/lateral) at physiologic rest positioning over time relative to CO/IP while using dental

physiologic healthy mandibular closure is when there is no mandibular/occlusal slide referenced from physiologically relaxed state of musculature.

Functional Occlusal Assessment: Terminal Occlusal Contact Quality

Functional chewing cycle tests using computerized mandibular scanning (jaw tracking) dynamically records the quality of the terminal contact position during gnathic mandibular function and TM joint movements (Figure 4a and 4b). Aberrant skids and lateral occlusal forces can be identified and recorded in both the sagittal, frontal/lateral

and horizontal planes. Broad terminal contact patterns are indicative of occlusal dysfunction contributing to masticatory dysfunction and orofacial pain symptoms. Narrow and more precise terminal contact during functional chew and open and closing cycles are indicative of occlusal health. Masticatory function is improved and TMD/orofacial symptomology is eliminated back to physiologic health.

Once a physiologic mandibular position and occlusal location is determined the clinician can objectively assess whether to equilibrate and or to add up via the use of a GNM orthotic as a means to test and validate masticatory stability and optimal occlusal functional balance.

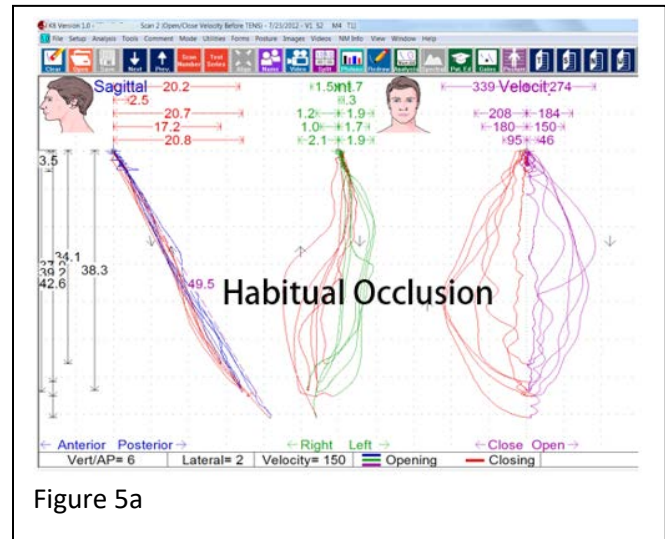


Figure 5a

Figure 5a: CMS K7 Scan 2 showing dysfunctional movements quality before GNM orthotic.

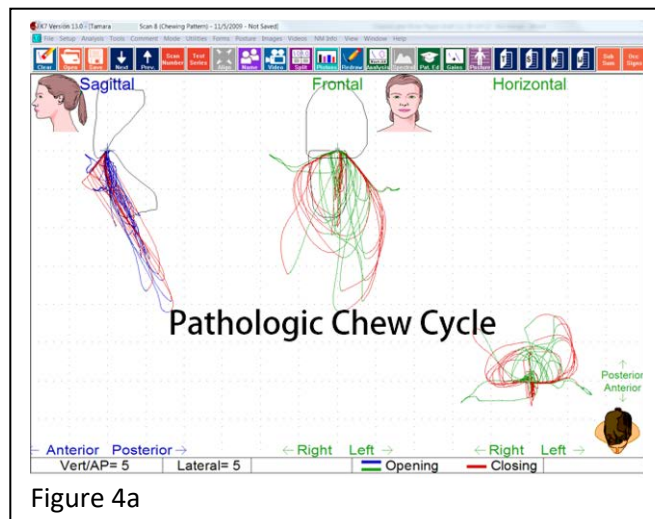


Figure 4a

Figure 4a and 4b: CMS: K7 Scan 8 - Physiologic (healthy) vs. dysfunctional (pathologic) chew and opening and closing cycles using Myotronics K7 kinesiograph displays the quality of terminal contact position of a patient before and after GNM orthotic treatment.

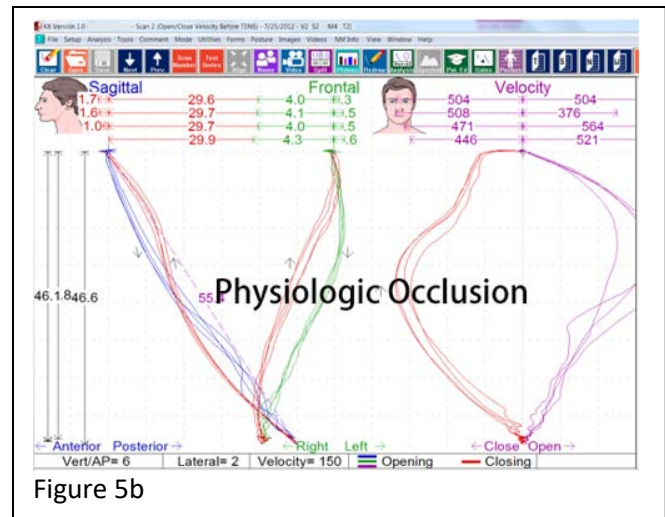


Figure 5b

Figure 5b: CMS Scan 7 showing healthy movement quality with no guarding of occlusion at terminal velocity – after GNM orthotic.

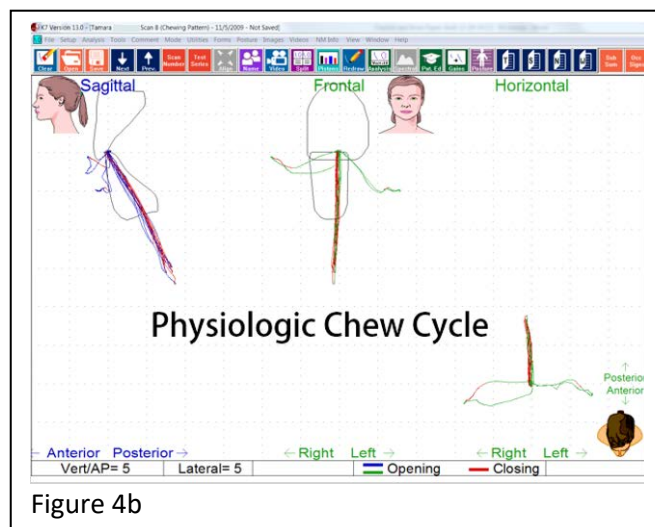


Figure 4b

Mandibular opening and closing cycles are also used to test the velocity, quality opening and immediate closing ability of the patient when closing to a terminal contact position (Figure 5a and 5b). Patients with dysfunction typically display a slow-down or guarded occlusion with diminished velocity (closing timing) below 250 mm/ss when closing into a pathologic (poor occlusal) position. A physiologic healthy occlusal position displays a terminal velocity closing pattern greater than 250 mm/ss. A broad/flat terminal velocity pattern at centric occlusal contact shows a healthy occlusion. A narrow velocity

pattern at terminal contact is indicative of unhealth - dysfunction/impairment.

Occlusal GNM Orthotic Therapy

The GNM Orthotic (GNMO) is a removable appliance used in compromised masticatory structural, pain and temporomandibular joint derangement conditions that have been uniquely determined based on physiologic and objective measured parameters. It is an appliance that requires the dentist to implement both gnathic as well as neuromuscular techniques and principles in his/her treatment planning. An accurate diagnostic neuromuscular analysis as well as precise execution of gnathic occlusal adjustments skills are required if the clinician and patient desires positive clinical outcomes.

Advantages of a precise GNM orthotic therapy:

- Improves muscle physiology, health and function.
- Improves overall head, neck and body postural alignment.
- Improves masticatory muscle activity, reducing myogenous pain.
- Reduces parafunctional clenching and bruxing.
- Reduces TMJ compression and retro-discal pressure in the temporomandibular joints.
- Accurate “orthopedic matrix” to guide restorative, orthodontic and surgical treatment.
- Reduces mobile teeth with periodontal compromised cases.
- Stabilizes the masticatory system and posture before finalizing treatment.
- Decreases noxious trigeminal nerve afferent/efferent proprioceptive signaling.
- Stabilizes the cranio-mandibular and cervical alignment and improves function.
- Conservative, removable, reversible and diagnostic.

The conservative, reversible and non-invasive nature of the GNMO is based on: 1) a comprehensive diagnosis by the dentist when determining the maxilla-mandibular vertical and antero-posterior relationship using instrumentation and 2) properly designing and occlusally managing the GNMO to meet the physiologic demands of the masticatory system. This appliance allows both the patient and dentist time to functionally test the quality of occlusal function and orthopedic positioning while at the same time achieving physiologic cranio-mandibular

improved alignment prior to any definitive treatment. The GNMO is adjusted and calibrated with electronic instrumentation that aids in determining objectively whether maximum physiologic dental health is being



Figure 6

Figure 6: Mandibular GNM Orthotic occlusal view. Posterior occlusal contacts mark and anterior contacts are balanced with Dental TENS, jaw tracking and EMGs to enhance precision and accuracy of gnathic lateral excursions and neuromuscular terminal function. Anterior central, lateral incisor and cuspid contact paths are designed to coordinate with optimal physiologic mandibular positioning in 6 dimensions – removes mandibular, cranial and cervical torque.

achieved or not during treatment therapy.

A trial (test) period is essential when using this type of removable appliance to determine whether the patient is free of pain and masticatory dysfunction, especially in cases with pain and joint derangement. Changing an occlusal scheme just for the sake of altering a scheme for the convenience of dental cosmetics can be a risky proposition in potentially making the patient’s symptoms worse if underlying pathologies are not identified during the diagnostic trial test period. Not recognizing or acknowledging the often-hidden musculoskeletal signs and symptoms in the everyday practice violates the dentist’s moral obligation of a health provider. Critical requirements of fabricating a GNMO not only include the gnathological design principles, but equally important how the maxilla-mandibular (bite) relationship is achieved and precisely managed intra-orally (Table 1).

The GNMO is hallmarked by its unparalleled therapeutic effectiveness that addresses the central nervous system (CNS) responses at the neural and muscular levels of the entire stomatognathic system.^{41, 100} The GNMO is refined

within 20µ level with gnathological principles of canine guidance and balanced contacts on an optimized myo-trajectory (an isotonic closing path) using the aid of the K7 kinesiographic jaw tracking sensor array (Myotronics).

This technology also aids the dentist in identifying where to better position the mandible to prevent unwanted muscle strain and cranio-mandibular cervical torque.

Table 1: Measurable Tests, Factors and Physiologic Parameters to Quantify GNM Orthotic Quality and Treatment Effectiveness in Reaching Maximum Dental Improvement (MDI)	
CMS K7 Scan 4/5 with Dental TENS - Confirms Physiologic Mandibular and Occlusal Position	<p>When occlusal adjustments are made posteriorly, too anterior and or slightly laterally to an optimal myo-trajectory (neuromuscular mandibular closing path) muscle function is diminished and impaired.</p> <p>0.2 square mm discrepancy or greater must be ground (adjusted) relative to the sagittal plane to accommodate closure to CO.</p> <p>Frontal/lateral adjustments must be made within 0.2 mm or less to accommodate unstrained closure and avoid guarding of occlusion.</p> <p>Occlusal adjustments must be made so mandible is opening and closing along an isotonic mandibular closing path (myo-trajectory).</p>
EMG K7 Scan 11- Confirms Quality of Muscle Recruitment Ability	<p>EMG muscle recruitment patterns are indicative of diminished or impaired mandibular function.</p> <p>When occlusal adjustments are made to a vertically deficient jaw position muscle recruitment (clenching) ability will be 150 mV EMG amplitude or less (unsustained).</p> <p>When functional clench muscle recruitment activity is not able to sustain for a 2 second period and EMG amplitude displays less than 150 mV this is indicative of dysfunction and impairment.</p> <p>Symmetry of occlusal EMG balance occurs when the peak EMGs are +/- 20% bilaterally.</p>
CMS K7 Scan 2 (before) and Scan 7 (after) - Confirms Mandibular Functional Position	<p>Lack of precise occlusal adjustments will contribute to dysfunction and impairment of the masticatory system.</p> <p>When mandibular opening and closing velocity is diminished to less than 100-150 mm/sec on closing it is considered poor or guarded occlusion.</p> <p>Adjust any occlusal premature contact interferences that are contributing to diminished masticatory function and imbalance.</p>
CMS K7 Scan 8 – Confirms Quality of Functional Chew Cycle	<p>During chew cycles when the terminal closing contact position is greater than 0.2 sq. mm this is indicative of poor or guarded occlusion confirming mandibular dysfunction and impairment.</p> <p>Adjust any occlusal premature contact interferences that are contributing to diminished masticatory function and imbalance.</p>
EMG K7 Scan 12 – Confirms Quality of Occlusal Balance	<p>When balancing the mandibles first tooth contact recruitment position, temporalis anterior and masseter muscle EMG patterns should show synchronous EMG rise (occlusal balance) during voluntary clench along the isotonic mandibular myo-trajectory.</p> <p>EMG patterns that do not show balance activation within 5 mV will contribute to before and after clench CNS hyperactive conditions indicative of hidden masticatory dysfunctions and occlusal impairment.</p>

Functional Occlusal Assessment: Impairment vs. Physiologic Health

Objectively validating the “quality” of the mandibular position (location) in addition to physiologically determining the terminal contact balance and function the clinician today is able to use EMG testing to measure functional muscle recruitment ability of the TMD patient. Electromyography is a means to measure muscle activity, quality of muscle recruitment ability during functional clench as well as measure quality of muscle rest (Figure 7a and 7b).

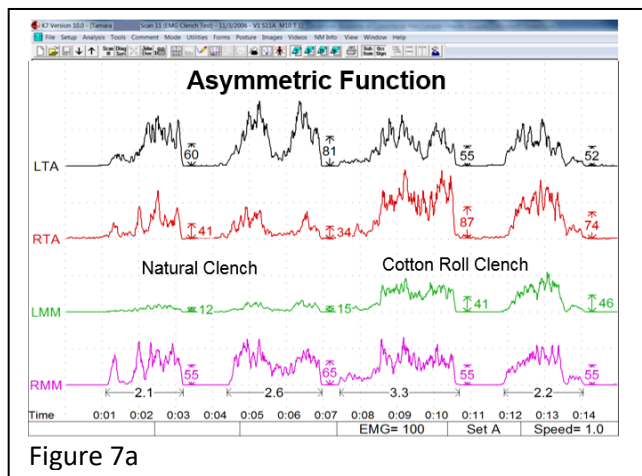


Figure 7a

Figure 7a: Asymmetric Functional muscle recruitment clench using EMG K7 Scan 11 – Lower EMG amplitude during repeated natural teeth and cotton roll clench test indicative of impaired muscles.

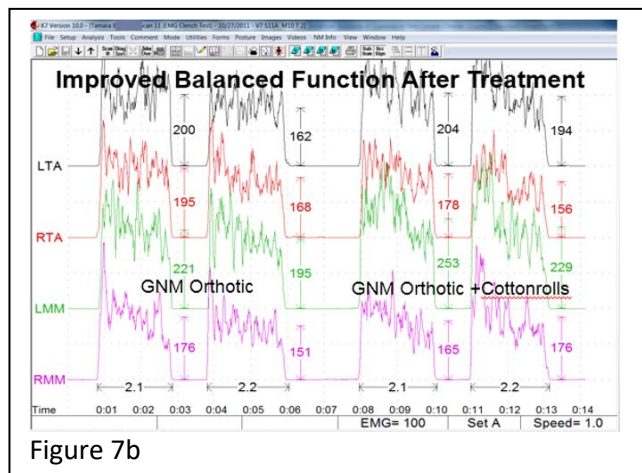


Figure 7b

Figure 7b: Improved EMG amplitude during repeated functional clench with occlusally refined GNM orthotic placed intra-orally and with cotton roll test with orthotic indicative of balanced muscles firing and improved mandibular positioning.

Functional EMG activity is usually lower in TMD patients when they are symptomatic than are the same patients when they are asymptomatic.^{57, 100, 121-123} The International Classification of Impairments, Disabilities, and Handicaps - ICDH defines impairments as “losses or abnormalities of physiologic, psychological or anatomical structure of function”.^{124, 125} Muscle balance during function has been correlated with muscle recruitment patterns and occlusal balance. There is evidence based on controlled studies that used extensive statistical test that maximal bite force and the electrical muscle activity during maximal bite in the intercuspal position are significantly weaker in patients with functional disorders of the masticatory system than controls without such disorders.^{124, 129, 148}

“In a carefully controlled study of voluntary isometric biting forces at maximal and submaximal levels, Molin (1972) demonstrated that there were "progressively increasing force differences between the (control/healthy subjects and patients with mandibular pain dysfunction syndrome (MPD). The joint study conducted at University of Karolinska and University of Gothenberg in Sweden concluded that “the patients generally produced only one half to two thirds of forces produced by the control subjects.”¹²⁵

Note: It is possible to have balanced occlusion with low EMG amplitude during an occlusal clench. This would indicate unresolved physical impairment. Poor muscle recruitment (low EMG amplitude readings) below 150 mV are objective measurements indicating physical occlusal dysfunction.

- A reduction in SEMG amplitude during a functional clench test is a clear indication of a physiologic impairment.
- There is a linear relationship between the strength of a muscle and the amplitude of the integrated EMG.^{126, 127}

Low tapering and aberrant EMG amplitude unbalanced patterns are indicative of pathologic occlusion and dysfunction – physical impairment (Figure7a). Sustain functional high EMG amplitude patterns that are balanced during clenching modes are indicative of physiologic occlusal health (Figure 7b).

Occlusal Refinement and Its Effect on the Central Nervous System

First tooth contact and EMG balance-response-timing-tests by the K7 computer's Scan 12-EMG (See Figures 6-11b) allows the treating dentist to establish a true physiological balance on an optimal mandibular closing



Figure 8

Figure 8: Mandibular GNM Orthotic refined to even contact to < 20µ marking film. Even dots on posterior teeth and balanced excursive cuspid discluding paths on anterior teeth indicate an optimal occlusal scheme based on an optimized myo-trajectory path of mandibular closure.

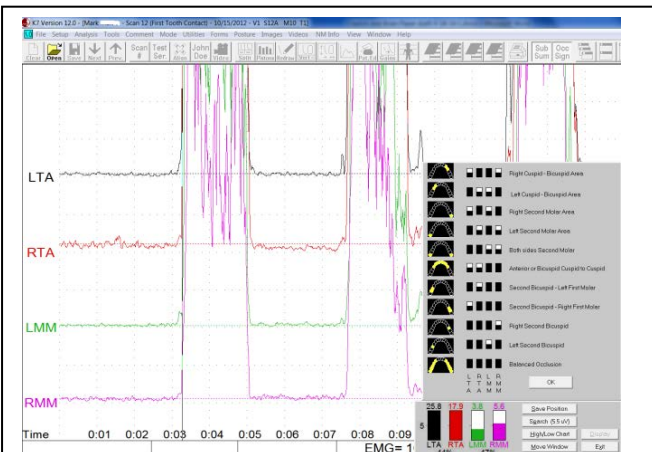


Figure 9

Figure 9: EMG K7 Scan 12 EMG first tooth contact muscle firing patterns correlating location of occlusal prematurities on same GNM orthotic showing 44% on left (LTA) and right (RTA) temporalis and 47% left (LMM) and right (RMM) masseter muscle imbalance during closing force on teeth despite even looking articulating film markings.

arc (myo-trajectory=habitual trajectory) (Figure 3b) that is

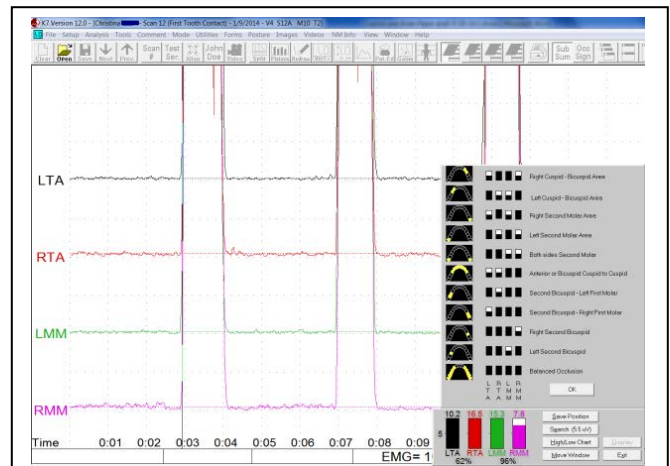


Figure 10

Figure 10: After multiple micro occlusal adjustments, the K7 Scan 12 EMG first tooth contact muscle firing patterns shows balanced muscle occlusal contacts on GNM Orthotic. Note the resting status of left and right temporalis anterior (LTA/RTA) and left and right masseter (LMM/RMM) muscles before and after closure indicative of calm central nervous system (CNS) and muscle health.

in harmony with total muscle health and function which goes beyond the standard methods of balancing occlusion with patients habitually biting down on articulating paper or occlusal wafers, which is subjective, not always effective and does not confirm a physiologic (ideal) mandibular closing path.¹⁰⁰

This test is a highly amplified EMG recording (EMG gain = 10) that goes beyond the Scan 11 functional clench test which is measured at an EMG gain of 100. This ten-fold means of measuring muscle timing and occlusal terminal contact balance is another objective measured test to not only confirm EMG muscle occlusal balance at a very high level, but further indicates the quality of the central nervous systems (CNS) proprioceptive resting status before and after a terminal occlusal EMG muscle recruitment.

Quiet resting EMG patterns (zones) before and after terminal clench can be recorded and observed as to how well the CNS is responding to the clinician's occlusal treatment. Calm anterior temporalis anterior and masseter muscle resting activity is recorded and should not display aberrant EMG spiking activities during resting periods prior to terminal closure (functional clenching) neither immediately after the functional clench (resting period). If there remain any

post synaptic EMG responses after the clench and or aberrant muscle activity when the teeth are apart (at rest) even if the occlusion was so called EMG balanced, the clinician should ask the following three questions:

- 1) Is the occlusion and or intra-oral appliance properly occlusal adjusted and balanced?
- 2) Is the position of the mandible in a proper physiologic location relative to the maxillary arch

when establishing an occlusion that supports homeostasis and optimal function during immediate jaw closure and resting modes?

- 3) Are the TMJ disc reduced if there is any presence of TM joint derangement?

Each of these mentioned factors relate to the CNS proprioceptive occlusal responses and helps to define what quality of occlusal intervention is employed to address whether the TMD patient is still left in a state of dysfunction (impairment) or improved to physiologic functional health (homeostasis). This is another key insight into the quality of a GNM occlusal TMD finish case – advancing one’s EMG interpretation and understanding. All treating clinicians should understand and realize the occlusal management goes beyond the simple concept of looking for even contact paper marks during classic equilibration protocols commonly taught in dental education today. Occlusal balancing involves not just the teeth, but the proper diagnostic assessment of the relationship between the mandibular and maxillary arches, along with their associate structures involving the teeth, muscles, temporomandibular joints and the unseen (hidden) effects on the central nervous system.

Only after a dentist has fully executed to the best of his or her abilities prudent, judicious care as a licensed dental care provider and evaluated the occlusion to these standards, should the remaining unresolved myogenous orofacial pain be considered for referral to those best qualified health care providers who can address any remaining problems that would prevent the patient from reaching maximum dental improvement. In the author’s opinion, too often the treating dentist will not find the etiology of the pain, because of lack of diagnostic skills, ability and or training in dental occlusal management, and ends up referring the patient to others providers, dismissing the problems as non-dental or iatrogenic. However, the absence of evidence of a malocclusion in the clinicians understanding is not evidence of absence in the actual clinical situation.

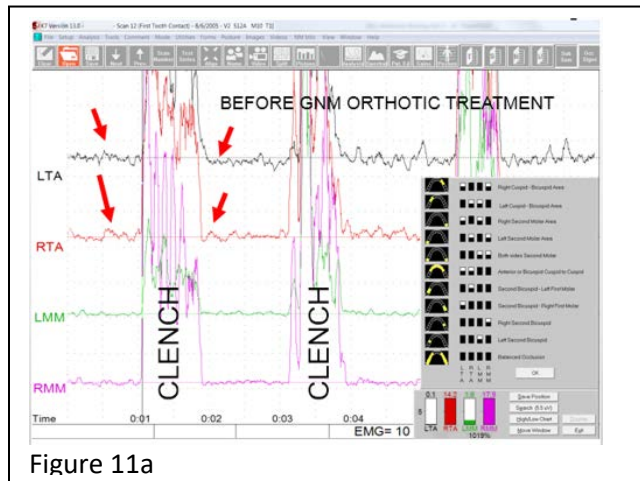


Figure 11a

Figure 11a: EMG K7 Scan 12 Proprioceptive CNS signaling responses displays 3 natural dentition clenches before in the habitual accommodated position. (Note: the aberrant and hyperactive EMG signaling before and after clenches indicative of pathologic interferences to the CNS).

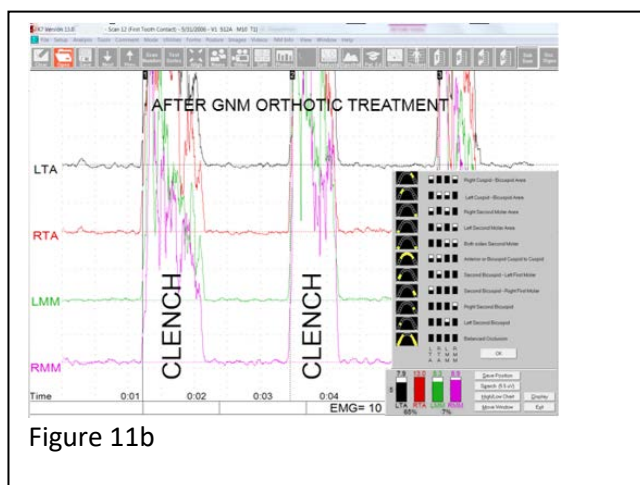


Figure 11b

Figure 11b: EMG K7 Scan 12 Proprioceptive CNS signaling responses displays 3 clenches after GNM orthotic treatment. (Note the calmer quiet EMG signaling before and immediately after each clench indicative of healthy stable CNS – homeostasis, true physiologic rest).

Reaching Maximum Dental Improvement

GNM orthotic treatment effectiveness recognizes a number of measurable factors in order to reach maximum dental improvement (see Table 1 and 2). Computerized mandibular scanning (CMS/jaw tracking)

plays a significant role in identifying objectively an optimal (physiologic) mandibular position, quality of function and quality of terminal contact balance. CMS aids the clinician to identify hidden occlusal slides and occlusal prematurities for optimal orthotic adjustment and balancing. A voluntary mandibular closing trajectory must be coincident with an involuntary isotonic

neuromuscular mandibular closing path to reach maximum dental improvement. Patient comfort is a treatment objective. The patient should be able to sleep, chew and function 24/7 comfortably free of pain and dysfunction when wearing any intra oral occlusal appliance, when it is occlusally adjusted properly.

Table 2: Requirements for Orthotic Fabrication

Requirements:	Comment:
Stable orthotic	Orthotic base is molded to an accurate bubble free cast. The model cast is accurately recorded using full arch poly vinyl impression material.
Comfort on placement	Any internal surfaces of the orthotic are relieved from excessive pressure against a tooth.
Comfort to tongue and lips	Smooth all surfaces with acrylic resin burs, rubber wheels, and polish with pumice. Buccal borders extensions are at the gingival margins of the posterior teeth tapered with a tapering extended lingual boarder from posterior distal gingival margins of second molars to avoid gagging reflex.
Precise occlusal contact	Stable, repeatable, comfortable. Involuntary mandibular closure should be coincident with voluntary mandibular closure- confirmed with Dental TENS and K7 CMS. Contacts on-teeth are balanced. Proper anterior and canine guidance resulting in "lines on the front, dots on the back".
Orthotic thickness	Minimum thickness 2.0 mm on directly lingual flange. Buccal-lingual borders 1.5-2.0 mm thick.
Occlusal coverage	Minimal occlusal coverage in the thinness area is no less than 1.5-2.0 mm for strength in the thinnest area inter occlusally.
Hard surface	Necessary for natural proprioceptive occlusal signaling of the CNS.
Complete arch coverage	Complete coverage avoids any tooth movement, intrusion of posterior teeth or orthodontic movements. Better retention.
Distal Extension	If there are missing teeth in the first and second molar regions the orthotic can be extended to complete a full arch for occlusal support and temporomandibular joint stability.

Discussion

The literature supports the objective analysis of the occlusion in TMD diagnosis. These studies span over 54 years; to date there is no literature that refutes the physiological model for masticatory muscle pain, the validity of the K7 technology, or the documented clinical results.^{45, 47, 48, 121-123,128-143} The K7 computer system (CMS, sEMG, and sESG) are recognized as safe and effective aids, by the U.S. Food and Drug Administration and the

ADA's Council on Scientific Affairs, in the diagnosis and treatment of patients with TMDs.^{134, 135, 143-144} K7 Technology is ADA and FDA approved and meets the standards of reliability and validity satisfying the requirements of sensitivity and specificity that are essential for clinical diagnosis of individual patients when establishing a cranio-mandibular jaw relationship for occlusal orthotics.^{145, 146} As Bernard Jankelson, D.D.S. once stated, "If it has been measured (objectively) than it is a fact; if it has not been measured it is an opinion".

The literature historically identifies the type of occlusal splint without objectively measuring the occlusion itself.^{28, 34} Studies that fail to measure and record the muscle health and function, occlusal contacts, TMJ health, mandibular arc and range of motion and quality of motion cannot make definitive conclusions about the effectiveness of occlusal correction and the effects on TMD with addressing these parameters.^{49-56, 128, 134, 142, 145-153}

Dentists today have technology available to them that allows precise measurements for objective data to create an ideal occlusion in the GNMO. Without exact measurement the dental occlusion will not be an optimized ideal occlusion for the patient, but another – different – malocclusion; and the goal of occlusal therapy is not to change the occlusion for the sake of change, but to deliver an occlusion that is homeostatic (physiologically neutral) with the patient’s masticatory system stable.^{28, 41} More so, taking a patient who has myogenous orofacial pain due to their existing occlusion and giving them a new malocclusion with limited ability to adapt will make them worse off than they were in the beginning. If the bite (occlusion) is not stable to these GNM parameters, then any occlusal balancing therapy will become unbalanced over time as muscle and joint dysfunction will dominate. If the treating clinician does not adhere to physiologic principles of occlusion any short-term gain in stability will not last and in the long-term will relapse back toward pathologic impairment and dysfunction.⁴⁴ Objectively measuring and quantifying one’s occlusal treatment, before, mid and after treatment is the only way to verify whether the clinician has truly achieved homeostasis (physiologic neutral), stable and optimal occlusion. Guessing or assuming one’s occlusal finishing results as stable is not scientific, neither is it evidence-based unless it is physiologically measured and quantified objectively.

Orofacial pain patients cannot avoid the effect of traumatic occlusal contacts without dental treatment; as a mechanical problem requires a mechanical intervention.^{38, 130} A treatment approach based on accommodation to symptoms is not ethical if an existing structural cause is not identified and treated. Traditionally it is considered ethical to treat patients who present with pain, infection or loss of function, whereas accommodation – as a primary goal – is not considered a desired outcome. It is unethical to just palliatively treat pain without addressing the underlying etiology because a dentist did not look for

the etiology.^{14,15, 21, 22, 104} Second, with traumatic occlusion the situation only gets worse as time goes on as the whole system continues to degrade and become more painful and less functional – “disability”.

Many in our health care profession are trained to diagnose and treat myogenous orofacial pain that is related to occlusion. To say that pain or dysfunction is a psychosocial problem without ruling out a physiologic and structural cause without assessing the dynamic function of the masticatory system is certainly making a gross failed diagnostic assumption - that is unethical.

An optimized GNMO is not only therapeutic, but over time is diagnostic. The dentist is not altering the patient’s presenting dentition, orthodontically moving or extracting teeth. The non-invasive, reversible, and conservative GNMO isolates the variable of the actual occlusion allowing for a systematic, logical, definitive diagnosis and clear understanding of the causative link between the presenting occlusion, TM joint derangement problems and myogenous orofacial pain.^{35, 145} The ability to identify the correct occlusion, and therefore any deviation from that – a malocclusion, is paramount as it has implication to not only paining patients but all aspects of dentistry for the clinician. While not all patients will want or need an ideal occlusion, it is prudent to bring this to light when any equilibration (occlusal adjustment or modification procedures, the placement of any intra-oral appliance, restorative dentistry, orthodontics, oral-surgery, or any other invasive dental procedures are being considered as part of the treatment process.

The GNMO must be designed and engineered to meet all the requirements of the physiology of the gnathosomatic system which includes the functional occlusion, patent airway, normal tongue function, cervical spine alignment and a stable central nervous system (Figure: 3-5, 7, 9-11).

A properly designed GNMO will allow the patient to wear it 24 hours per day, every day, removing it only for oral home care and hygiene. It should allow speaking, eating, swallowing, exercise and sleeping without irritating the patient's functional demands (Table 2). The GNMO is implemented based on scientifically sound GNM principles with a terminal occlusion on an isotonic myotrajectory.



Figure 12

Figure 12: Mandibular GNM Orthotic frontal view. Anterior teeth and palatal cusps of the maxillary posterior teeth contact the GNM orthotic synchronously.



Figure 13

Figure 13: Mandibular GNM Orthotic right lateral excursion. The maxillary anterior incisor comes into contact to distribute the muscle force during the excursive movement over several teeth. This transitioning incisal tooth contact allows the GNM orthotic to disclude the posterior teeth to the full extent of the border movement.



Figure 14

Figure 14: Mandibular GNM Orthotic left lateral excursion. Maxillary incisors share balanced forces during the excursive movement for optimal patient comfort, stabilizing and coordinating jaw, TMJ and cervical neck kinematics.

Conclusion

Myogenous orofacial pain is a common and significant presenting problem to today's clinician. The ability to objectively identify the patient's existing occlusion and their physiological occlusion is essential to relieve pain and prevent further problems whether the patient is a restorative, cosmetic, orthodontic or TMD-paining patient. An accurate diagnosis and proper treatment plan must be done to determine the scope and limitations of treatment. The medical and dental community today are using various modes of instrumentation and technology to objectively quantify and support their findings. If dysfunction or impairments are present in the masticatory system it can be documented and found by means of:

1. Computerized jaw tracking instrumentation (CMS) that is able to give "objective verifiable documentation" of jaw position, range of motion, quality of function and quality of terminal contact management.
2. Electromyography (EMG) – objectively measure muscle resting modes and function modes relating to occlusal contact and timing.

3. J5 Dental TENS – stimulates the neuromuscular masticatory system to produce an involuntary mandibular myo-trajectory and aids in TM joint decompression.

Combining these technologies with the gnathologic principles of occlusal management the dentist is able to better assess, evaluate and treat the TMD/orofacial pain patient comprehensively.

After objectively measuring the entire gnathic and neuromuscular system a GNMO is fabricated and occlusally fine-tuned adjusted to physiologic objectively measured parameters beyond the traditional subjective methods. The GNMO is non-invasive, conservative and

a logical approach meeting the patient's myogenous orofacial pain needs reducing TMD headaches and a constellation of musculoskeletal symptoms. It is an effective diagnostic intra-oral appliance which up holds the principles of anatomical form and function, allowing both patient and dentist to enjoy the effect of physiologic health.

Disclaimer

The authors have no financial, economic, commercial, or professional interests related to topics presented in this article.

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