Neuromuscular Orthotics in the Treatment of Craniomandibular Dysfunction and the Effects on Patients with Multiple Sclerosis: A Pilot Study

Tammarie Heit, D.D.S.

ABSTRACT: The purpose of this pilot study was to identify, measure and document an effect on the subjective multiple sclerosis symptoms and compare it to any objective data changes in the neuromuscular system of the head and neck, following the correction of the jaw position using a neuromuscular orthotic. The hope is to provide clinical evidence of improvement in the disease long-term without relying on the subjective evidence of remissions and exacerbations reported by the patient. The evidence found in the current pilot study measured improvement of head position, jaw position, jaw function, and airway in the neuromuscular bite position, which correlated with the improvement of subjective symptoms of craniomandibular dysfunction and multiple sclerosis. Studies show that the bite affects blood flow in the brain, which may explain the improvement of the patients in the current study.

0886-9634/2901-057$05.00/0, THE JOURNAL OF CRANIOMANDIBULAR PRACTICE,

Manuscript received February 1, 2010; accepted June 9 2010

Address for correspondence:
Dr. Tammarie Heit
9415-100A Street
Edmonton, Alberta
Canada T5K 0V4
E-mail:
scotiasquare@interbaun.com

Dr. Tammarie Heit *graduated with distinction from the Faculty of Dentistry, University of Alberta, Edmonton, Alberta Canada in 1996. She is a graduate of The Las Vegas Institute for Advanced Dental Studies, current president of The Multidisciplinary Association For The Study of Cranio-Cervical Pain (MASCCP) in Edmonton and holds a mastership at the International College of Cranio-Mandibular Orthopedics (ICCMO). Dr. Heit is the Canadian Regent for ICCMO, a member of The International Association of Comprehensive Aesthetics, The Canadian Dental Association, and The Alberta Dental Association and College. Dr. Heit has a general dentistry practice in Edmonton, Alberta.*

Multiple sclerosis is a progressive, chronic disease of the central nervous system characterized by destruction of myelin off the axis cylinders of nerve fibers. The loss of myelin creates a 'plaque' seen on MRI that interrupts the flow of nerve impulses along the nerve that results in a variety of symptoms and dysfunction, depending on which nerves are affected (**Figure 1**).

Common symptoms that vary in onset and severity include spastic paraplegia, speech disturbances and nystigmus. Other visual disturbances, such as diplopia and blindness also occur. Cerebellar lesions can cause intention tremors, loss of tonicity and balance. There can be slow, monotonous, slurred speech, spastic weakness of the extremities, and loss of abdominal reflexes. Loss of connections between the cortex and basal ganglia can result in emotional hyper excitability, euphoria and depression. Damage to the pathways to the sacral plexus can result in bladder, rectal and genital disturbances. Loss of the myelin sheath on the vestibular nuclei or their connections can cause nausea and vomiting.[1-8]

Multiple sclerosis is one of the most disabling diseases of young adults in Canada, affecting people between 20-60 years of age in the prime of their life. The incidence in Alberta has increased from 20.9 to 23.9 per 100,000 from

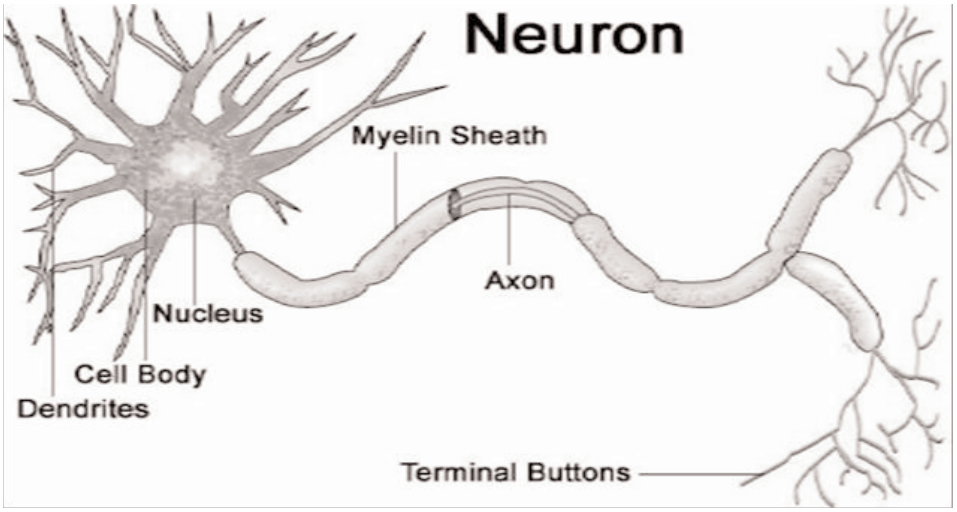

Figure 1
Illustration/drawing of the neuron.

1990-2004, affecting more females than males and a slight shift in diagnosis to the younger years. Thus, the social, medical, psychological and economic impact is devastating to the patient, their families and to society,[9,10] (**Figure 2**).

Multiple sclerosis is characterized by periods of long remissions and exacerbations, which makes the disease very difficult to study. There is no known cause or cure for multiple sclerosis but research suggests that it is precipitated by an autoimmune response. Epidemiology indicates that this disease is rare in tropical countries and more common in northern areas where the climate is cold and damp. There is also research that suggests causes related to neck injuries, vitamin D deficiency or a virus. Since there is no known cause, there is also no cure. Many different drugs and treatments have been tried, but it is difficult to assess their effectiveness because a large percentage of patients will show spontaneous improvement.[1-8]

We, who practice neuromuscular dentistry, have noticed a great improvement in the well-being of our patients far beyond the dental benefits.[11-20] There have been many informal reports to me of patients who have multiple sclerosis and other neurological diseases who were treated with a neuromuscular orthotic for their craniomandibular dysfunction and who have improved dramatically. The importance and success of "open minded observation of watching and wondering" was not lost on Nobel Foundation Award Winner in physiology Nikolaas Tinbergen in 1973.[21] The technique used to develop the neuromuscular orthotic uses biomedical instrumentation, which measures a deviant condition as fact rather than

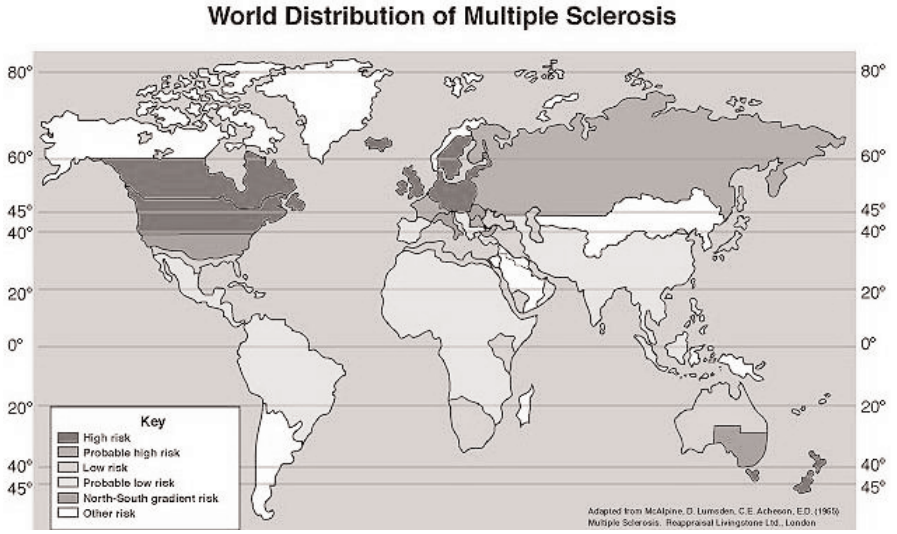

Figure 2
World distribution of multiple sclerosis.

opinion.[22,23] This provides an opportunity to evaluate people with multiple sclerosis more objectively in searching for answers regarding the disease.

Other studies have shown improvement of the multiple sclerosis with the decompression of the brain stem using NUCCA chiropractic techniques.[24, 25] Those studies are retrospective and subjective in nature but are relevant because the alignment protocol corrects a measured parameter of the atlas related to the axis. This provides objective evidence of treatment similar to the neuromuscular orthotic. The 'hold' of the atlas to axis is more permanent if it is built into the occlusion, because the bite is the 'top block' or most distal joint negating the requirement for regular adjustments by the chiropractor to 're-locate' the alignment. This is described and proven in a Chicago study documented by Dr. Norman Thomas that has yet to be published.[26] There is a reciprocity between head posture and jaw function.[20,27-31] The alignment of the spinal column seems to be influenced by the occlusion.[19,32]

This begs the question, "Is the long-term, subtle compression of the brainstem and reduced flow into the brain helping trigger the autoimmune response, which causes the demyelination?"[33-38] Studies documenting the relationship between the bite and the brain over the last 30 years show that the answer to this question may be 'yes,' and as the development of advanced technology progresses—the past studies are being reinforced by the newer ones.[12,13,21,23,28,39-45]

And, "What about the geographic incidence? Are all the other findings related to sun exposure, vitamin D, cold climates, etc. just aggravating this pre-existing, subtle physical deformity and triggering the manifestation?" It was shown by Wick, et al.,[33] that "there is no single mechanism that is responsible for the development of autoimmune diseases" and that a "multitude of factors finally results in the emergence of clinically overt autoimmune disease."

"One of the most important and intensively studied immunoendocrine feedback loops works via the hypothalamo-pituitary-adrenal (HPA) axis, resulting in down-regulation of immune functions mediated by glucocorticoid (GC) hormones.[33,35,46] The occlusion affects the HPA axis as well. The stomatognathic triad consists of the occlusion, the temporomandibular joint and the neuromuscular system. It is the afferent input to the masticatory system which is proprioceptive on the 5th cranial nerve. The trigeminal nerve is the only cranial nerve which has its nucleus in the brainstem. There are no synapses with direct communication to the mesencephalic nucleus of the reticular activating system which directly affects the HPA axis."[22,23]

Can this explain some of our clinical findings? Will our ability to measure jaw function to establish neuromuscular harmony with measured evidence enable us to stop or even reverse an autoimmune disease such as multiple sclerosis? It has been said and proven in laboratory studies that "the reestablishment of just one of the tolerance-inducing mechanisms may be sufficient to prevent or contest autoimmune reactions."[33,35,46,47]

It has been well demonstrated that the neuromuscular bite is related to the position of the neck and subsequent decompression of the jaw joints.[12,29,39] This results in a change in the upper cervical vertebrae and decompression of the brainstem. Decompression results in dramatic reports of well-being in patients treated using neuromuscular dentistry.[11,14,48]

Materials and Methods

Eight patients were admitted into the pilot study who had a positive diagnosis of multiple sclerosis from their medical doctor, using magnetic resonance imaging[6-8] to observe the plaques formed in the brain. There were seven females and one male. The age range was 21-47 years old. These patients also had the diagnosis of craniomandibular dysfunction (CMD), following a detailed dental examination, which revealed the appropriate signs and symptoms[22] in the head, neck and dentition and allowed me, as a general dentist, to treat them.

Documented measurements using dental cast analysis, cone beam computerized tomography (CBCT) scanning (computerized tomography), sonography of the jaw joints, EMG's (electromyography), jaw tracking, airway diameter, atlas/axis alignment, photography and other objective data was assessed, before and after treatment with the neuromuscular orthotic, and related to the subjective symptoms reported by the patients. These data were compared to the exact same data gathered from the control subjects.

All the patients had a medical and dental history, a full dental exam with routine x-rays, and documentation of their neuromuscular and MS symptoms. There was an iCAT (Imaging Sciences International, Hatfield PA) scan of the head and neck completed in full occlusion, in the neuromuscular position (on the myobite in the controls or the orthotic in the treated subjects) and with the jaw wide open. There were pretreatment photographs, K-7 scans using the Myotronics equipment (Myotronics, Inc., Seattle WA), TENS (transcutaneous electrical neural stimulation of cranial nerves v, vii, xi) for 45 minutes to relax the jaw muscles, and a bite record taken on neuromuscular trajectory, following the TENS.[22] Further K-7 scans and iCAT scans were done with the myobite in place to help verify the position.

Four of the eight patients, two with severe CMD and two with mild CMD, were chosen randomly and a fixed neuromuscular orthotic was fabricated by the Aurum laboratory (Aurum Ceramic Dental Laboratories Alberta Ltd., Edmonton, Alberta Canada). The fixed orthotic was inserted and adjusted every 1-2 weeks following 45 minutes of TENs[11,22] (transcutaneous electrical neural stimulation), and their subjective symptoms were documented relating to both their temporomandibular disorder as well as their symptoms of multiple sclerosis (**Figures 3**-**10**).

All eight patients were required to record their subjective symptoms at the beginning, during, and at the end of the three month study.

The symptoms were rated from 1 to 10 with 1 being 'no symptom' and 10 being 'worst possible' (Visual Analog Scale - VAS). The symptoms asked for CMD were headache, neck pain, face pain, pain while eating or chewing, jaw joint pain, stiff jaw, jaw clicking or popping, tired face muscles, jaw doesn't open or close straight, unstable bite, ear stiffness, ringing in the ears, difficulty swallowing and throat pain.[11,22]

The symptoms asked regarding MS were visual disturbances, nystigmus, diplopia, 'scanning' speech, fatigue, intention tremor, spastic weakness of the arms and legs, rigidity, paralysis of the arms and legs, loss of abdominal reflexes, emotional hyper excitability, vertigo, depression, bladder disturbances, constipation, genital disturbances, swallowing problems, breathing problems, and sleeping problems. Some patients had other symptoms

Figure 3
Close up of the bite **without** the fixed neuromuscular (NM) orthotic.

Figure 4
Close up of the bite **with** the fixed neuromuscular (NM) orthotic.

Figure 5
Side view of the relaxed face **without** the fixed NM orthotic.

Figure 6
Side view of the relaxed face **with** the fixed NM orthotic.

Figure 7
Side view of the smiling face **without** the fixed NM orthotic.

Figure 8
Side view of the smiling face **with** the fixed NM orthotic.

Figure 9
Front view of the smiling face **without** the fixed NM orthotic.

Figure 10
Front view of the smiling face **with** the fixed NM orthotic.

not on the questionnaire that they documented, and those were also monitored.[5-8]

The patients were then asked how they felt overall and whether they thought they were better, worse or the same in terms of their CMD and their MS. This was compared to their detailed recordings done throughout the study.[49]

The subjective findings that were reported by the patients were as follows:

1. Dramatic improvement in the CMD in the two patients who had severe CMD with mild and moderate improvement in the multiple sclerosis symptoms initially.

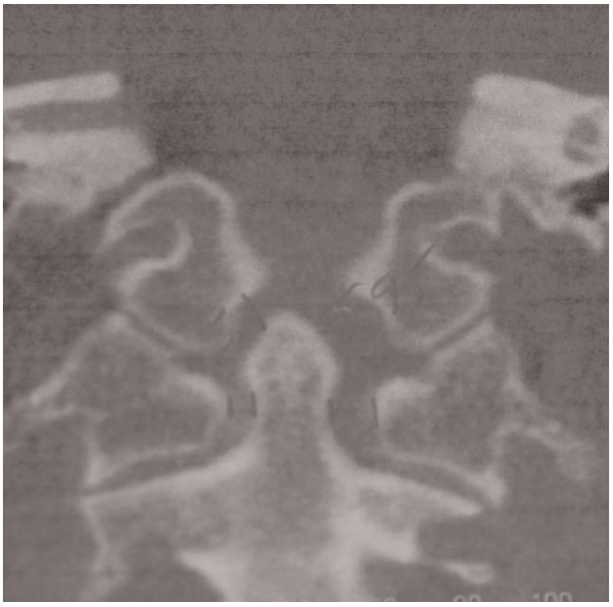

Figure 11
CBCT image of the atlas related to the axis of the cervical spine **without** the fixed NM orthotic on the teeth.

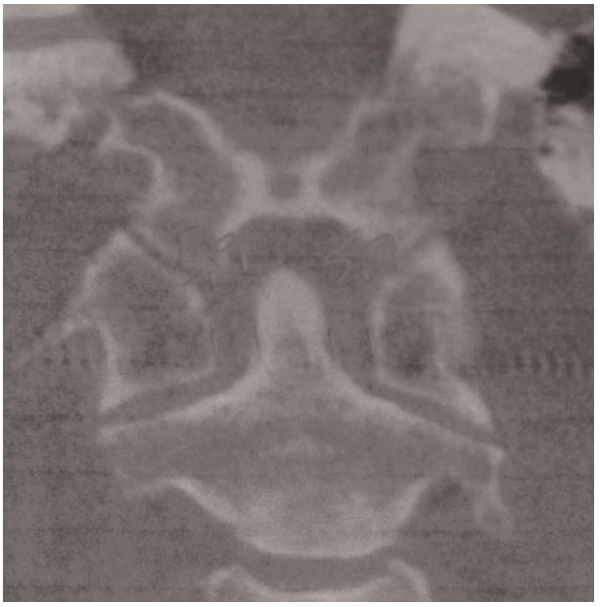

Figure 12
CBCT image of the atlas related to the axis **with** the fixed NM orthotic in in place. Note the improvement in the symmetry of the positioning of the atlas related to the axis.

2. Mild improvement in the other two patients with mild CMD and no improvement in the multiple sclerosis symptoms.
3. No change in the two control subjects with regard to both the CMD and the multiple sclerosis.
4. Worsened MS symptoms in two control subjects with no change in the CMD.
5. The overall report from the patients ranged from the same as the detailed report to underestimating their improvement generally.[49]

The two patients with the dramatic improvement purchased the orthotic for permanent use following the completion of the study. Those two patients have opted for permanent relocation of their jaw as supported by the teeth because of the dramatic improvement. The two other patients who experienced the effects of the orthotic requested a permanent bite transfer done in case they wanted to reinsert the orthotic in the future. Six months after the study, one of those patients came forward and requested her neuromuscular orthotic be reinserted.

The use of subjective data alone was not enough due to the placebo response the patients might have in their responses to a study such as this.[49] It was important to have controls and strict measures in place so that none of the patients knew who was being treated and who was not. The following measured, physical data is important along with how it correlates to the subjective data expressed by the patients.

All the iCAT scans were analyzed for abnormality in the PAN (panograph) extraction, tomograms of the jaw joints in centric occlusion, neuromuscular occlusion and wide-open jaw identifying shape and position[48,50,72] of the condyle, as well as space in the TMJs. There was analysis of the lateral cephalogram[51] using the modified Sassouni plus technique[15,52-55] along with observation of the condition of the stylomandibular ligament.[56-62] The measurement of the atlas and axis in all jaw positions with comparison to jaw function in scan 19 was done.

The panoramic views were used for screening the overall jaw presentation in centric occlusion and neuromuscular occlusion for each candidate. It is recognized in dentistry that there is distortion associated with this view, but its value as a screening tool is recommended.[58,63] All panoramic views were extracted from the digital data in the same way for comparison purposes. Information regarding the teeth, sinuses and bone was noted for each patient, but it was the differences between the centric and neuromuscular occlusions that were important for this study. The differences identified in the PAN between the habitual occlusion (CO) and the neuromuscular occlusion (NM) was related, using the teeth to reference the position of the maxilla to the mandible. The condylar position relative to the temporomandibular fossa was screened in CO and NM, although a more accurate representation for condyle-fossa relationships was found in the tomograms of the joints.[58,64-68]

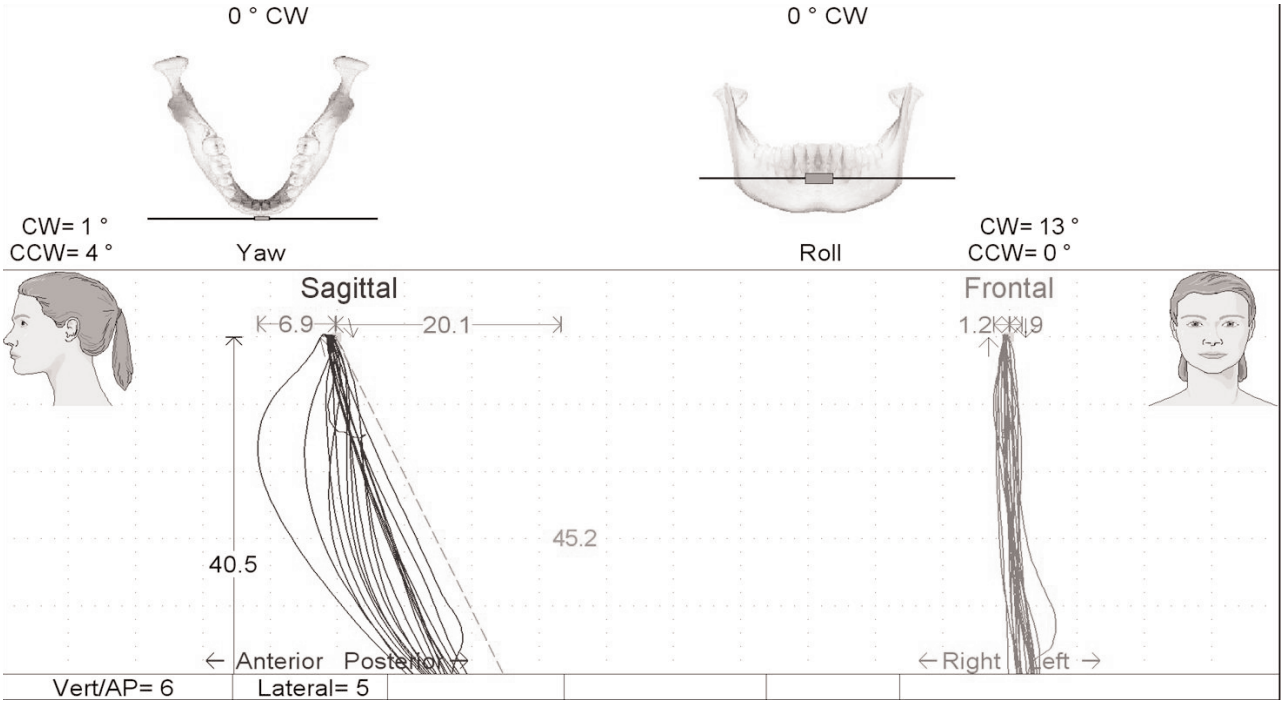

Figure 13
Scan 19 recording of the functional roll and yaw movements of the mandible opening and closing **prior** to the insertion of the fixed NM orthotic.

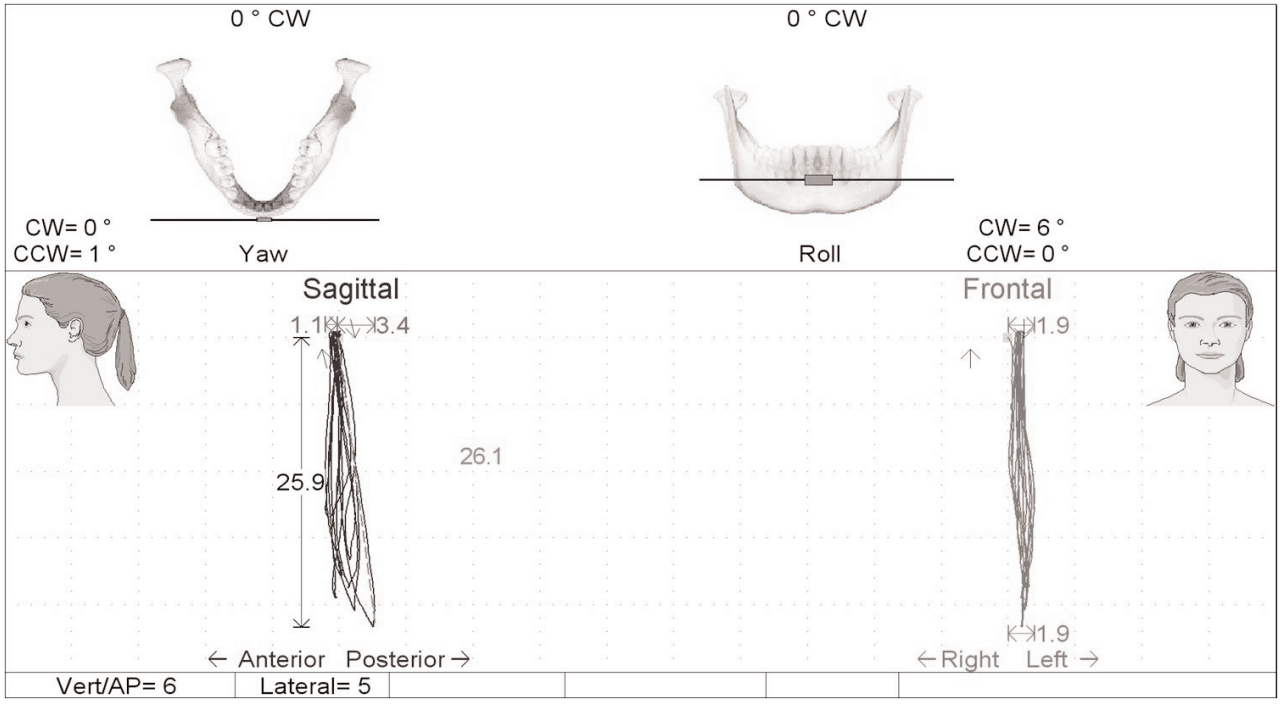

Figure 14
Scan 19 recording of the same patient after insertion of the fixed NM orthotic on the teeth. The clockwise roll has improved by seven degrees, compared to the same amount of change in the atlas related to the axis of the cervical spine measured from the CBCT images.

In all cases, there was an increased appearance of space in the condylar fossa in the PAN views confirmed by measurements in the tomograms in the neuromuscular position, indicating the down and forward movement of all the mandibles. This was seen in the controls on their myobites and in the treated patients on their fixed orthotics. The PAN views of the jaw joints are widely known to be inaccurate,[58,69] but as a screening tool did generally compare to the measurements found later in the tomograms. The tomograms are widely accepted as accurate with no distortion.[58,63-70] The increased space indicates a decompression of the TMJ, which resulted in relief of symptoms associated with TMD[11,22,48,58,63,71] in the treated patients and not the controls.

A short scan was done of the TMJs with the mouth wide open to determine hypermobility. None of the MS patients had the head of the condyle go past the height of the eminence in CBCT; however, two of the patients measured past 50 mm clinically, suggesting hyper mobility of the jaw joint. There may be an under-diagnosed incidence of hyper mobility in the population,[58] but in this study, the incidence clinically was 25% in a select population of people with CMD.

Seven of the eight patients had beaking of the condyles in different degrees in the tomograms of the jaw joints. This 'beaking' is bony remodeling of the condyle, which represents the accommodation of the body trying to increase the space in the jaw joint in response to a posteriorly positioned jaw by the patient's occlusion.[14,22,48,50,72] It is a degenerative change in the condyle indicative of craniomandibular and temporomandibular dysfunction related to the occlusion.[14,22,48,50,69,71-73]

In four of eight patients, there was roughness of the head of the condyle indicative of degenerative joint disease, which also showed up as high frequency markings in the sonogram in scan 15. This denotes long-term overloading in the TMJ with the loss of cartilage and bone on the head of the condyle.[50,69,72]

In the cephalogram views, a modified advanced sassouni analysis was done, as it helped predict the neuromuscular jaw position and relates to the K-7 functional analysis.[15,18,54,55,74,75]

In the current study, it was found that the neuromuscular bite, obtained by the Myotronics equipment using EMGs, restored the vertical and anteroposterior dimensions needed as predicted by the arcial analysis of the cephalogram.

In all cases, the cephalogram analysis showed an increase of the vertical dimension with the neuromuscular bite.[40] In the cases with the most dramatic symptom relief, the vertical dimension was increased to the point predicted in the Sassouni anaylsis. In one case, there was a loss of numbness in one leg.

For the A/P measurements, the neuromuscular position improved the cephalogram analysis to skeletal Class I from the Class II position or kept it at the same Class I position that it started with.[69,73]

The stylomandibular ligament was isolated from the tomograms, using MIP filtering in the lateral cephalometric view to assess calcification. In six out of eight MS patients, the stylomandibular ligament was calcified to at least the upper 1/3. Calcification of the stylomandibular ligament in the general population is fairly common (18.2% in review of 1771 panographs[57]); however, TMD like symptoms associated with it are not (only 1% to 5%[56]). None of the patients in the current study had symptoms associated with Ernest Syndrome; however, the incidence of calcification of the stylomandibular ligament was higher than in the general population.

It is well documented that occlusion affects the cervical posture.[12,13,16,19,26,27,29-32,39-42,62] In this study, there was a change in the cervical spine when the neuromuscular bite was inserted. This was measured using the occlusal plane related to the dens of the atlas. The patients with the biggest discrepancy between their habitual occlusion and the neuromuscular occlusion had the largest change in the atlas related to the axis and the biggest improvement in the symptoms of CMD and MS. This can be related to multiple sclerosis.

In a retrospective analysis done by Erin L. Elster,[24,25] who is a NUCCA (National Upper Cervical Chiropractic Association) chiropractor, it was found that in 81 cases treated by correcting the atlas/axis relationship, 91% of patients with multiple sclerosis and Parkinson's disease had improved and/or reversed symptoms with no further progression of the disease over five years.

Comparison of the atlas (first cervical vertebra) to the dens of the axis (second cervical vertebra) was done in the sagittal and axial views of all the patients in the centric and neuromuscular bites using CBCT imaging.[13,16,23,26,28,39-42] In all cases, there was a measurable discrepancy between the positioning and symmetry of the atlas and axis, which improved with the neuromuscular bite also reflected in the improvement of scan 19. These measurements related to the presentation of the patient with regard to their forward head posture and pathological loss of the natural sclerotic curve in the cervical spine. Again, the increase in difference of the measurements between the two bites related to an increased difference, relating atlas to axis, the severity of the TMD symptoms, and the improvement of those symptoms with the neuromus-cular bite.

The measurements were done in two ways. The first

was from a frontal view measuring the lateral curves of the odontoid process of the axis from a certain reference point to the medial areas of the atlas on a horizontal plane. The centric occlusion and neuromuscular occlusion data was extracted from exactly the same points in a 0.4 mm slice of the two scans, using subtle landmarks uniquely identified and clarified in each individual. The magnification and settings in the toolbar were replicated and identical for each scan. The distance between the determined reference points identifies a space on each side of the odontoid process of the atlas and the lateral borders of the axis adjacent to it. This distance was compared in the centric and neuromuscular bites and related the axis to the atlas in each case. The neuromuscular bite either maintained or improved the symmetry of the space in the A/P view of the atlas related to the axis in all the cases. The controls did not change significantly (**Figures 11**, **12**).

The second way was measured from the axial view from lateral points of the odontoid process of the axis to the lateral body of the atlas in order to try to get a 3-dimensional analysis. Also, printouts were made of the axial views in two different cuts and angles, relating atlas and axis and compared before and after the three-month time frame. This time, the vertebral foramina of the axis were identified and an optimal 0.4 mm slice was clarified in each of the CO and NM studies.[76] The slice was marked and frozen for printing. Then, a slice from the atlas using the most pronounced curvature of its inferior and anterior border was duplicated in both the CO and NM studies. This was also marked and frozen for printout. The computer printed out side by side, both the atlas slice and the axis slice, using the same settings. A line was drawn from the sharpest points of the inferior borders of the vertebral foramen in the axis straight through the atlas printed out beside it. The pronounced curvatures identified on the atlas were connected to form a second line that created an angle with the first line. This angle represents the change in the relationship of the atlas to the axis in a rotational dimension from the habitual bite to the neuromuscular bite.

A scan 19 was performed on both the habitual bite and the neuromuscular bite. The patient was fitted with the sensor array headgear of the Myotronics equipment. A special magnet was placed securely with adhesive on the anterior gingival margin in the lower central incisor area at the mandibular skeletal midline using the frenum as a reference point. The patient was positioned in good posture, and the sensor array was calibrated in the usual fashion. The patient was instructed to open the mouth as wide as possible at normal speed 10 times, landing on the habitual bite in one scan sequence and the neuromuscular bite in a second scan sequence. The computer traced the lower jaw movement in 2/6 dimensions by tracking the magnet on the sensor array.[22] The dimensions of *yaw* and *roll* were recorded in this scan, and the degree of deviation was documented for each opening and closing motion (**Figures 13**, **14**)

The angle obtained in the printout from the CBCT scans related to scan 19 of the Myotronics equipment that measured the patients' yaw and roll functional jaw movements. As the printout angle became smaller on the neuromuscular bite, so did the roll measured in the functional jaw movement documented in scan 19 using the same bite.

The treated patients showed a change in all measurements of atlas related to axis when going from centric occlusion to the neuromuscular bite at the three-month mark. The controls maintained the same measurements on admission and at the three-month mark.

To date, the author is not aware of any studies verifying that the CBCT scan images of the atlas and axis can be compared to scan 19, which documents and measures a functional jaw movement with any accuracy. The CBCT scans are accurate and not distorted,[51,64-70] but the accuracy of the measurements of those CBCT scans done on the computer or on printouts are still being researched by the various companies who sell the equipment.

The severity of the discrepancy and symmetry of the atlas within the axis related to the severity of the presentation of the severity of the TMD, malocclusion, beaking of the condyles, and space in the jaw joints. This also related to the patients' documentation of the overall improvement of their symptoms over three months in the treated patients.

More compelling was the relationship of these measurements to the scan 19 done using the Myotronics K-7 computer, documenting the live functioning of the yaw and roll of the patient's jaw during 10 opening and closing cycles. There was fewer yaw and roll deviations documented in the neuromuscular position than in the centric occlusion in six out of seven cases (one case had a missed scan). The measurements were done using both the static iCAT data and the nonstatic functional jaw movements documented in scan 19 and correlated consistently with each other. With the advanced measuring techniques using computer software yet to be perfected and studied in a controlled environment proving accuracy, analysis of this type of data will prove to be very exciting.[77-80]

There is documentation that the bite and neuromuscular response[29,81,82] affect the airway.

The airway was assessed from an axial section in CO and on the neuromuscular bite in two different scans. The same section of the airway was chosen at a 0.4 mm slice

by coordinating the frontal views of the odontoid process and the axial views of the smallest airway opening to get the exact same exposure using the cervical spine as a reference point. The airways were measured in a vertical and horizontal plane of the axial slice to compare the change in sizes. A study[77] done at the University of Southern California proved that this technique is an accurate measure of airway that corresponded to patients diagnosed with sleep apnea.

In 15 comparisons between the NM bite and CO, the size of the airway was larger in eight cases, the same in one case, and smaller in six cases. When the airway was compared in the same sitting on the same day in seven cases, the NM airway was larger than the CO airway in four of the cases. This comparison was done to help eliminate patient positioning from the equation when measuring airway, but at the time of the study, the technician was unaware of maintaining perfectly the same patient positioning before the scan. A strict protocol and an experienced, well-trained technician is required to eliminate positioning as a factor in the interpretation of the results in future studies.[65]

The airway was also measured using a volumetric tagging from the CBCT scan between the hard palate and the lowest cervical vertebrae detected.[77] In seven comparisons between the airway in CO versus NM done on the same day, the neuromuscular airway was larger in five of the cases and the same in one case. It has been shown in other studies that measured airway that CBCT is an accurate estimate of airway size in 3-D intra- and intraobserver, following protocols for training and calibration.[64,65] Observing the airway in 3-D correlated to the results using the axial slice technique, which was proven in a study done measuring obstructive sleep apnea patients.[77]

Overall, the NM airway appears larger than the CO airway in the current pilot study.

Following the completion of the analysis of the CBCT data gathered on the habitual and neuromuscular bite, K-7 scans and cast analysis of the dentition was done to further evaluate objective data on the patients diagnosed with multiple sclerosis.

The K-7 scans using the Myotronics equipment measured the EMGs, jaw tracking, sonograms, freeway space, neuromuscular trajectory, mandibular range of motion, and masticatory muscle function, coordination and fatigue.[11,22,83] A total of 186 scans were done. The scans were consistently done as per the protocols outlined in Dr. Jankleson's book[22] and as per the latest recommended techniques by Myotronics.[83] There were protocols for each scan that included strict lead placement, patient positioning, and technique to obtain the best scan possible with every measurement to eliminate any extraneous variables. Scans performed were bilateral EMGs of the temporalis, masseters, anterior digastrics, and sternocleidomastoids before and after TENs; muscle function studies in the designated occlusion and on cotton rolls; muscle fatigue studies on the baseline occlusion, the neuromuscular occlusion, before and after TENs in the beginning of the study and at the three-month mark; sonography on the baseline occlusion and on the myobite or orthotic (NM); jaw tracking that included yaw and roll measurements, freeway space, range of motion, occlusal stability and velocity readings. The scans were done exactly the same way, both in the controls and in the treated subjects. The scans were rated as improved, unchanged or deteriorated when going from habitual occlusion to neuromuscular occlusion using measured data. The scan was rated as improved when the readings moved toward normal[22,84] ranges by more than a 10% average from the initial baseline scan to the second scan reading. The scan was rated 'unchanged' when they were within 10% of the baseline reading either toward or away from the normal parameters. The scan was rated 'deteriorated' when moving away from the normal direction by more than 10% average.

The total scans that *improved* were 39 with 30 of those going to the treated subjects and nine improved scans in the control subjects. The total scans that deteriorated were 14 with 10 deteriorated scans in the treated patients and four scans worse in the controls. The total scans unchanged were 40 with nine scans staying the same in the treated patients and 31 scans the same in the control subjects. There were 18 missed scans that could not be evaluated for technical reasons. The same number of scans was evaluated on the treated patients as the control patients. The final impression of this measurable evidence is 61% improvement in the treated patients and 20% improvement in the controls. There was 21% deterioration of scans in the treated patients and 9% deterioration in the control subjects. Eighteen percent of scans were unchanged in the treated patients and 69% were unchanged in the controls. Therefore, a significant change in measureable, functional data occurred in the patients who were treated with the neuromuscular orthotic that did not occur in the controls. This data is consistent with other studies measuring the same thing[11] from a craniomandibular perspective, but also correlates to the symptom improvement in the multiple sclerosis manifestations.

One of the most important scans to note is scan 18, which measures muscle fatigue following a 10 second clench. Scan 18 was done on admission and following 45 min TENs. If the fatigue resolved following the TENs,

the patient was noted to have a *descending* cause of the fatigue that related to the occlusion. If the fatigue increased following TENs, then there are *ascending* issues complicating the patient's presentation that need to be addressed in addition to the treatment with the orthotic. This important concept was noted by Dr. Norman Thomas in the treatment of craniomandibular dysfunction using neuromuscular dentistry and involves complex issues related to the whole organism, which requires a multisciplinary approach to their treatment.[47,85] In the current study, the requirement of the multidisciplinary approach to treatment of the patients presenting with ascending CMD was **NOT** employed thereby, affecting the results in a negative way.

Of the eight patients studied, five had the descending variety of CMD, which means that the occlusion was the primary cause of the fatigue since TENs of nerves V, VII and XI supplying the muscles of mastication improved the readings. Three of the patients had more fatigue following TENs (ascending CMD)—one of those patients was treated and the other two were controls. The random selection of treated patients was done before knowledge of this result. In this study, 37.5% of the patients presented with ascending CMD. Fortunately, this translated to only 25% of the treated patients, since the neuromuscular treatment is not complete without a multidisciplinary approach. It is interesting to note that the only treated patient that did not request the reinsertion of the orthotic was the one with the ascending variety of CMD.

If a formal study is engaged in the future, it would be vital to address this important issue to ensure the full and proper neuromuscular stabilization of the treated individuals. That could be use of a foot orthotic in the case of a patient with a short leg or the use of the services of a NUCCA chiropractor or physiotherapist, depending on what the ascending issue is.

Another way to handle this issue would be to eliminate all the individuals presenting with ascending CMD from the study and look at only those whose occlusion is the primary cause of the neuromuscular dysfunction.

A cast analysis was done on all the subjects' dental casts using the Schwartz-Korkhaus Analysis[18,74,86,87] to measure maxillary and mandibular arch width and length. All eight MS patients had narrow maxillary and mandibular arches. Seven subjects had short premaxillas and one individual had a long but very narrow premaxilla. The more severe cases of CMD had the narrowest arches and had the most improvement in both their CMD and symptoms of MS.

Twenty-one common signs of CMD[12,19,22,73,83] were also identified and evaluated on the casts. The casts represent the long-term evidence on the teeth of a malposition of the jaw that the subjects presented within the current study. The signs evaluated were crowded lower anterior teeth, wear of lower anterior teeth, lingual inclination of lower anteriors, lingual inclination of upper anteriors (division 2 occlusion), bicuspid drop off, depressed curve of spee, lingually tipped lower posteriors, narrow mandibular arch, narrow maxillary arch, midline discrepancy, malrelated dental arches, flared upper anterior teeth, wear facets, locked upper buccal cusps, fractured cusps, chipped anterior teeth, loss of molars, open interproximal contacts, crossbite, anterior open bite, and deep bite.

All eight patients had between 11-16 of 21 signs. Again, the patients with the worst CMD had the most and severest of the 21 signs. The treated patients with the most and worst signs improved the most using the neuromuscular orthotic.

Results

It has been demonstrated that the neuromuscular position of the jaw will correct the position of the head over the body, align the bony tissues, preventing nerve dysfunction, and increase the efficiency of the circulation of nutrients (air, blood) through the neck and brainstem into the brain.[12,13,16,22,23,26,28,39-42,44,45,48,62] If so, does a chronic, very mild compression of this blood flow to the brainstem result in an autoimmune response that causes demyelination in the brain—used to diagnose MS?[33,47]

Is the history of an injury to the neck left untreated or undiagnosed causing some sort of change to the nerve function or blood flow to the brain that triggers an autoimmune response that is MS as the body heals and accommodates to the injury?[47]

Is this mild injury to the brainstem a result of direct trauma, trauma induced by malposition of the jaw, or both? Is an individual predisposed to the exacerbation when female, vitamin D deficient, or exposed to colder climates?[33]

The evidence found in the current pilot study measures improvement of head position, jaw position, jaw function and airway in the neuromuscular position, which correlated with the improvement of symptoms of CMD and TMD. In the case of multiple sclerosis, there was subjective symptomatic improvement in half the treated patients in a very short time frame with no improvement and deterioration in the controls.

The cases that presented with more severe CMD had the worst symptoms and veered farthest from the norm with regards to measurements of all the data gathered. Those were the patients that also had the biggest improvement in symptoms and improved the most with regard to

restoring their data measurements towards the normal. In those patients, there was a notable subjective improvement in their subjective symptoms of multiple sclerosis and CMD.

In two out of four of the treated patients in this pilot study, there was such a dramatic improvement in their wellbeing relating to the CMD and MS, that they were compelled to permanently change their bite with the neuromuscular orthotic. A third patient returned to the clinic six months after the removal of the orthotic to have it reinserted.

Discussion

An opportunity now exists to follow the patients and their multiple sclerosis to see if there is a change in their MRI measurements in the future. It takes 9-12 months for remyelination of the nerves to occur. Remyelination of the nerves can be quite robust.[88] However, in demyelinating diseases such as MS, there is documentation that remyelination is incomplete or inadequate and eventually fails in the majority of lesions.[89] There is interest in finding therapeutic strategies that can enhance the remyelination process of the nerves.[88,90,91] Is it possible that by addressing the cause of the demyelination in the first place (say if there is an autoimmune response to an abhorrent neuromuscular system), that the remyelination would be more effective? The key would be to assess for remyelination and symptom relief and then reassess long-term for the same things.

An MRI can be done to see if there is any improvement in the plaques in the brain that may correlate to the patient's symptoms of MS. If there is no improvement but no further development of new plaques, that would be significant, especially if it relates to an extended remission or stabilization from the patient's perspective.[49,92]

MS is a very tricky disease to investigate because of the long remissions, exacerbations, and the subjectiveness of the disease. Hard, measurable evidence is needed to nail down this elusive disease and guide clinicians to a cause and cure. What better hard evidence to follow than the demyelination of the brain, which is the marker used to diagnose MS in the first place.[2-8]?

Conclusions

The purpose of the current pilot study was to see if there was actually an effect on multiple sclerosis when the craniomandibular dysfunction was treated with a neuromuscular orthotic. It appears that there **IS** an effect that is measurable in both a subjective and an objective way. The difficulties with the study are that the orthotic used is limited to three months or else permanent changes occur, so the orthotics had to be removed before realization of the long-term effects it may have on the MS patient.

Luckily, two (possibly three) patients will voluntarily stay with the neuromuscular bite and now their MS can be monitored long-term.

The issue of diagnosing the craniomandibular dysfunction as 'ascending' or 'descending,' using scan 18 is an important and vital factor that was not controlled in the current pilot study. Perhaps, another study can be done on MS patients retrospectively. People with MS, whose bites have been changed to the neuromuscular position for other reasons can be followed up simply by doing an MRI and comparing it to a previous one. It is vital that these cases be identified and documented.

Finally, a large study, using many subjects, needs to be done to really evaluate the impact a neuromuscular orthotic has on people with MS. It has to be well-designed and controlled with strict protocol and meticulous detail, using the Myotronics equipment to its fullest extent by experienced neuromuscular practitioners to get the best results for the patients.

Long-term monitoring of patients who have permanently restored their occlusion into the neuromuscular position needs to be done to eliminate the compliance factor in determining the real effect that neuromuscular occlusion can have on people with MS. The motivation of the patient will be their improvement and well-being following meticulous stabilization by the dentist. Patients participating in the study who have a dramatic improvement in well-being can become the long-term cases needed by permanently restoring their occlusion to the new position. Then monitoring past long remissions can take place, as well as any MRI changes.

The obstacle will be the high financial cost associated with this treatment, as it is not covered by health care and requires a lot of clinical time, expensive, precision equipment and materials in the hands of specially trained neuromuscular dentists.

Alberta, Canada, has some of the highest incidence of multiple sclerosis in the world.[9] Alberta also has wealth associated with this disease,[10] available from government and private societies that have developed as a result of the social impact it has had on the community.[93] The progress of a formal, large scale study, developed from the intriguing results of this pilot study may well improve the quality of life of the thousands[9] of patients afflicted with multiple sclerosis. It may also prove to prevent the development of multiple sclerosis in high-risk individuals, as results from a larger study will surely shed some light on a solid, measureable cause for this elusive disease.

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