Airway Centric TMJ Philosophy

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ABSTRACT The airway governs our ability to breathe and to achieve a restful, oxygenated, restorative night's sleep, as well as to perform optimally during the day. Any temporomandibular joint or occlusal philosophy must address airway patency while managing pain and dysfunction, identifying contributing factors and alleviating perpetuating factors. The teeth are the last piece of the Airway Centric paradigm. The airway is the first, then joint and muscle and, lastly, the occlusion.

AUTHOR

Michael Gelb, DDS, MS, is an innovator in sleep apnea, painful TMJ disorders and other head and neck pain disorders. Dr. Gelb has studied breathing-related sleep disorders (BRSD), specializing in how they relate to fatigue, focus and pain, and their potential adverse effects. He received his dental degree from Columbia University School of Dental and Oral Surgery and a master's degree from the State University of New York at Buffalo School of Dental Medicine. He is the former director of the TMJ and Orofacial Pain Program and a clinical professor in the Department of Oral Medicine and Pathology at New York University College of Dentistry.

Conflict of Interest Disclosure: Michael Gelb, DDS, MS, is the co-inventor of the Airway Centric medical device and is the chairman and CEO of Gelb Technologies LLC. Historical portions of this content are from previously published material.

The airway guides the development of the nasomaxillary complex, mandible, temporomandibular joint (TMJ) and, ultimately, the occlusion of the teeth.[1-5] Occlusion is driven by the airway, and malocclusion and facial morphology are compensation for a narrowed airway. Airway Centric (AC) TMJ philosophy explains this important paradigm shift based on new research, with an emphasis on prevention of sleep disordered breathing (SBD), temporomandibular disorders and neurobehavioral disorders[5,6] (**FIGURES 1** and **2**).

The airway governs our ability to breathe and achieve a restful, oxygenated, restorative night's sleep, as well as to perform optimally during the day. Epigenetics[7] and phylogenetics[8] have made humans susceptible to airway collapse because of a variety of factors, including a descending epiglottis,[9] a floating hyoid, high narrow palate,[10] retruded constricted maxilla[4] and maxillomandibular retrognathia as well as enlarged tonsils, adenoids and tongue. In addition, current orthodontic technique[11] and nightguard fabrication may compress condyles and narrow pharyngeal airspace.[12] Environmental factors, such as feeding patterns, dietary characteristics, trauma, pacifier use, digit sucking, mouth breathing and swallowing habits, are also associated with malocclusion.[13] Airway narrowing and SDB lead to alterations in the nasomaxillary complex and mandible as well as to further malocclusion.[14]

The dentist plays a key role in airway health, as 90 percent of obstruction occurs behind the maxilla and mandible in the region of the soft palate, tongue and lateral fat pads.[15] The ear, nose and throat specialist (ENT) and orthodontist are also essential to establishing nasal and pharyngeal airway patency.

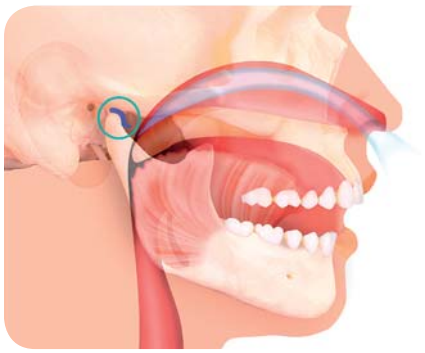

FIGURE 1. Closed airway.

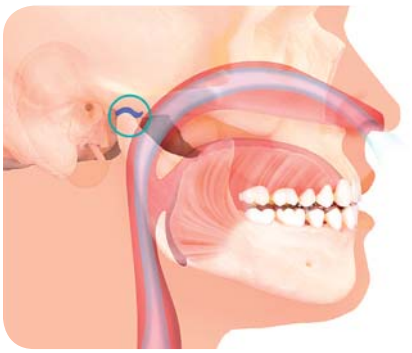

FIGURE 2. Airway Centric philosophy.

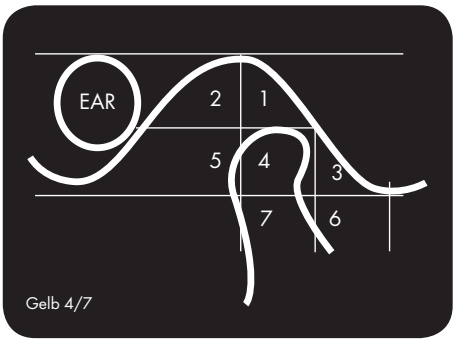

FIGURE 3. Gelb 4/7 position.

Any TMJ or occlusal philosophy must also include a nighttime component to address parafunction or bruxism because of the shearing forces to the joint[12] and increased tension of the cervical and masticatory muscles. Sleep bruxism is classified as a parasomnia or stereotyped movement disorder[16] with obstructive sleep apnea as a leading risk factor. Other etiologic factors are autonomic sympathetic cardiac activation, sleep arousal, neurochemicals, comorbidities (SDB) and psychosocial factors.

SDB, defined as mouth breathing, snoring, upper airway resistance syndrome (UARS), hypopnea and apnea, leads to sleep fragmentation and decreased stage-three restorative sleep. Decreased stage-three, or delta slow wave, sleep has been linked to fibromyalgia[17] and increased chronic pain.

Any TMJ or occlusal philosophy must address airway patency while managing pain and dysfunction, identifying contributing factors[18,19] and alleviating perpetuating factors. The teeth are the last piece of the AC paradigm. The airway is the first, followed by joint and muscle and, lastly, the occlusion and anatomy of the teeth. Prevention of temporomandibular disorders (TMD), malocclusion and neurobehavioral and neurocognitive issues[6] is the goal of AC TMJ philosophy and requires early identification and early intervention, although intervention can occur at any age.

History of Centric Relation Dentistry

My introduction to centric relation and the TMJ dates back to 1965 when I viewed the images my father, Harold Gelb, DDS, used for his lectures. It is now 49 years later, and the Gelb 4/7 position (**FIGURE 3**) has serendipitously evolved into the AC philosophy and the Gelb 4/7 Bite, Balance, Breathing method.

A little more history: In 1930 the fathers of gnathology, Harvey Stallard, PhB, PhD, DDS, Charles Stuart, DDS, and Beverly B. McCollum, DDS, followed Bonwill's mechanical occlusion theory[20] and translated the movement of the jaw to an articulator. The gnathologists developed a jaw position called centric relation (CR), which is the most retruded superior position of the joint (**FIGURE 4**). Some dentists referred to this jaw position as rearmost, uppermost or terminal hinge. The focus at that time was on the teeth and the occlusion and the way the teeth fit together and contacted in right and left lateral excursions. Other articulators were developed to support occlusal philosophies over the next 80 years, and include the Artex, Sam, Panadent, Whip Mix and Denar.

These gnathologists were revered and were inducted into the USC Dental Hall of Fame. Around the same time, Charles H. Tweed, DDS, had just graduated from Angle's School of Orthodontics and rejected nonextraction theory as producing faces that were too protrusive.[21] He began extracting permanent bicuspids to "flatten" profiles and supposedly give more stable results (**FIGURE 5**). Ron Roth, DDS, and Robert Williams, MS,[22] applied the CR concept to orthodontics in ensuing years. Over the next 40 years, the gnathologists and Tweed orthodontists contributed to a more retruded jaw position with fewer teeth (**FIGURE 5**). This jaw position was taught and utilized in American dentistry from 1930-1995 and is still taught in some parts of the country.

To dentists such as Bill Farrar, DDS, Barney Jankelson, DDS, and Harold Gelb, this made no sense. The condyle wars in the 1970s pitted gnathologists such as L.D. Pankey, DDS, Peter E. Dawson, DDS, and the Society of Occlusal Studies against Gelb, Farrar, Jankelson and John Witzig, DDS. Witzig taught the European school of functional orthodontics popularized by Laszlo Schwartz, DDS, and Christine Frankel, DDS, which used the Gelb 4/7 position in nonextraction expansive orthodontics. Witzig was the expert witness in a landmark legal case involving a four-bicuspid extraction patient who required TMJ surgery following extraction orthodontics. The patient received more than $1 million, a substantial settlement at the time.

In the 1980s Dawson, along with the authors of the glossary of prosthodontic terms,[23] realized that the gnathologists had no biologic or physiologic evidence for a retruded centric position. They followed Gelb, but with a more conservative anterior-superior position (**FIGURE 6**).

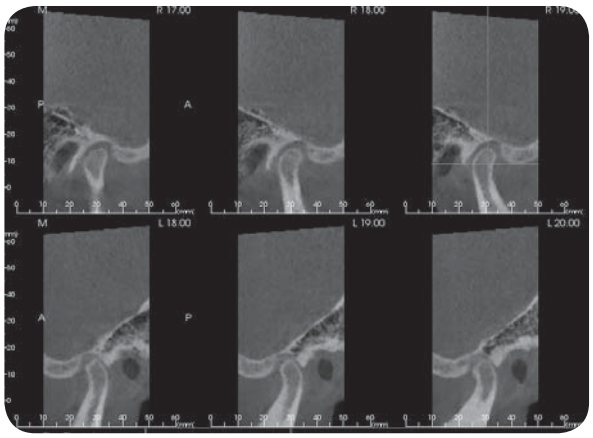

FIGURE 4. Old centric relation — retruded jaw position, 1930-1995.

Celenza[24] coined the term "long centric" after patients returned with their habitual comfort bites forward of the artificially retruded CR. Most prosthodontists and orthodontists still follow the "old" centric relation (**FIGURE 4**).

Psychophysiologically oriented Dr. Schwartz[25] popularized the myofascial approach to TMJ treatment at Columbia University in the 1950s, and Daniel Laskin, DDS, and Charles Greene, DDS, then advanced their theory of myofascial pain dysfunction at the University of Illinois in 1969.[26]

Working with arthrography in the 1980s, Farrar and W.L. McCarty, DDS,[27] in Montgomery, Ala., began to understand the workings of the TMJ disk. Further TMJ magnetic resonance imaging (MRI) research by Per-Lennart Westesson, DDS, and R.W. Katzberg, DDS,[28] elucidated normal and pathologic movements of the condyle disk fossa assembly. Farrar believed that TMJ internal derangement produced myofascial pain.

Controversy continued as neuromuscular dentists concentrated on muscles while surgeons and other TMJ dentists focused on internal derangements of the TMJ. Teflon proplast TMJ implants were a disaster, but there was moderate success with TMJ arthroscopy and arthrocentesis.

The triad approach of muscle-joint-teeth, which considered myofascial pain and trigger points as well as TMJ internal derangements, became popular in the 1990s and was taught by Henri Gremillion, DDS, and Noshir Mehta, DDS, among others.[29] It emphasized diagnosing joint and muscle pathology before looking at the occlusion.

Biopsychosocial research and theory published in the 1990s used research diagnostic criteria (RDC) from University of Washington faculty members Samuel Dworkin, DDS, PhD, Linda LeResche, ScD, and Edmond Truelove, DDS, MSD. The neuroscience group of the American Association for Dental Research (AADR) and the International Association for Dental Research (IADR) supported this philosophy and proposed reversible nonocclusal therapy, viewing oral appliances as unnecessary and mercenary. Unfortunately, most biopsychosocial researchers were not clinicians familiar with objective measurements found in polysomnograms (PSG) during sleep or with clinical pain management other than cognitive behavioral therapy.

AC TMJ Anterior Repositioning Therapy

Dr. Harold Gelb first described his mandibular orthopedic repositioning appliance in 1959[30] by placing the condyle in the Gelb 4/7 position within the glenoid fossa, slightly forward of concentric and against the eminence. This orthopedic technique was intended to three-dimensionally reposition the mandible in harmony with the neck, back and feet. Relatively decompressing the auriculotemporal nerve and TMJ could improve clicking, locking and shearing forces.[12]

According to *Craniofacial Pain: A Handbook for Assessment, Diagnosis and Management* from the Academy of Craniofacial Pain,[31] "There is now a consensus opinion that the Gelb 4/7 position correlates with the physiologic normal position for the TMJ condyle in the fossa."[31] Farrar and McCarty advocated a position similar to that of Gelb and Ireland.[27]

Positioning the mandible anteriorly using orthopedic repositioning has been shown to be efficacious for treating anteriorly displaced disks and to be superior to stabilization appliances or neuromuscular splints for relieving pain and dysfunction.[27,32-37]

Before AC TMJ philosophy (**FIGURE 2**) was developed, the Gelb concept of three-dimensionally repositioning the mandible to reestablish a normal disk condyle position, while establishing normal resting lengths of the masticatory muscles, was the most effective method of treating internal derangements of the TMJ and the accompanying pain and dysfunction of the masticatory and cervical muscles.[38,39]

Recapturing of the disk with anterior repositioning occurred in 52 percent to 70 percent of patients in two early studies[40,41] and 86 percent in a more recent publication.[42] H. Clifton Simmons, DDS, and S.J. Gibbs, DDS, showed recapture in 25/26 joints, or 96 percent, using MRI before and after appliance therapy.[35] Bite position for recapture was established using the Gelb 4/7 position, which represents a consensus of normal position of the condyles in the glenoid fossa.

While Harold Gelb continued to use the Gelb appliance, in 1989 the author, as director of the TMJ and Orofacial Pain Program at New York University, began using the NYU appliance, a modified

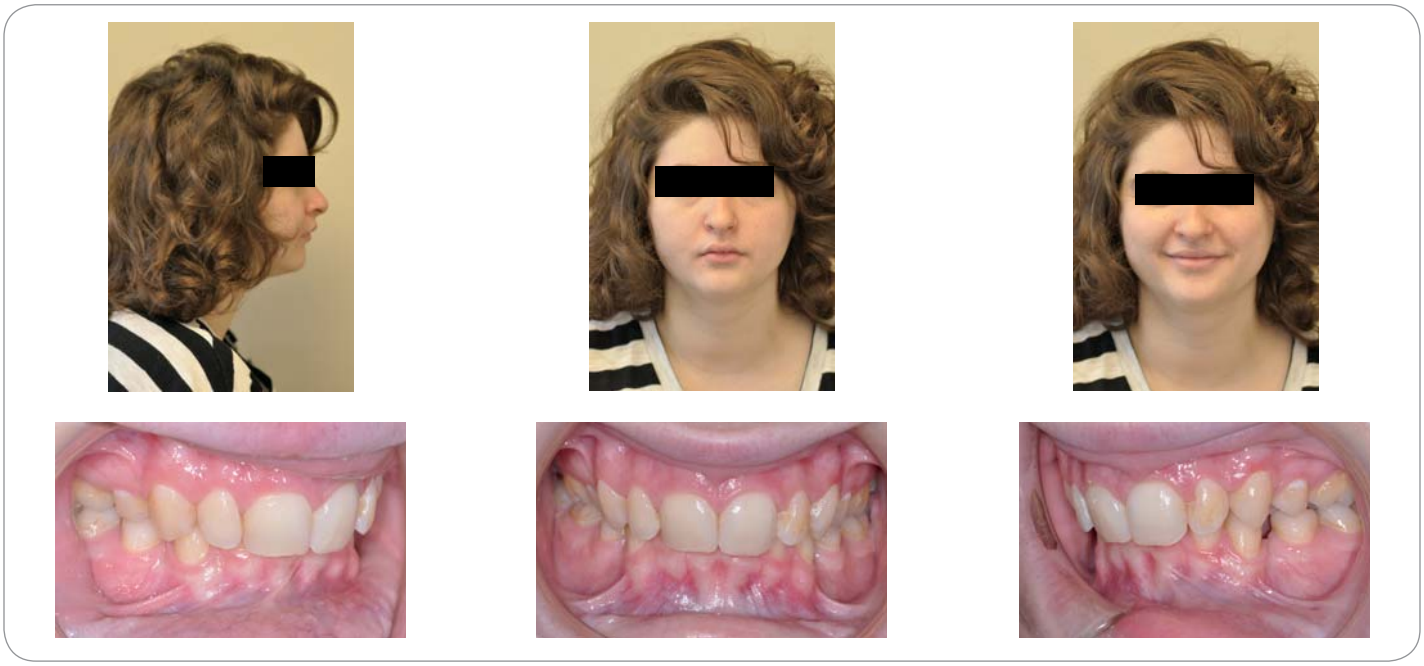

FIGURE 5. Four bicuspid case.

mandibular orthopedic repositioning appliance (MORA) (**FIGURE 7**). The NYU appliance covered the cuspids, which prevented intrusion and allowed for cuspid guidance, and placed acrylic around the linguals of the lower anteriors for stability. Both appliances worked best with occlusal indexing, which defined the new occlusion and gave increased proprioception while swallowing. Gelb and Gelb recommended a Farrar antiretrusion appliance at night for those patients with clicking or intermittent locking.[43]

Farrar[27] utilized a position very similar to the Gelb 4/7 in accordance with arthrography to reposition the jaw and maintain that position at night with the Farrar antiretrusion appliance.[27] Not only did Farrar prevent jaw clicking and locking during sleep, he, along with Gelb, serendipitously fabricated the first oral sleep appliances.

When the mandible retrudes to a retrognathic, or slack-jawed, position during supine sleep, the tongue and soft palate also retrude and collapse the airway. Nightguards traditionally fabricated in a terminal hinge-retruded position would also retrude the tongue and palate and lead to a collapsed airway. Gelb and Farrar were the first to go against the grain and maintain a forward position for an open airway during the day and at night.

Most of the TMJ/TMD research of the last 30 years has been measuring the wrong variables. With the advent of PSGs we can easily measure electrical activity of the heart with an electrocardiogram (EKG), electrical activity along the scalp with electroencephalography (EEG), electrical activity produced by muscles with electromyography (EMG), heart rate variability (HRV), CO_2 and O_2 saturation, as well as apnea, hypopnea, upper airway respiratory symptoms, arousals of the brain and body position with sound and video.

I propose that these objective physiologic measurements have already shown the efficacy of mandibular positioning appliances over the last 20 years, with multiple position papers published by physicians, sleep specialists and researchers.[44]

Sleep deprivation and SDB have profound effects on stage-three restorative sleep, which is necessary for repair and regeneration of musculoskeletal tissue, as well as on rapid eye movement (REM) sleep that is needed for well-being and memory consolidation. SDB also profoundly affects tissue inflammation, hypoxia and reperfusion, oxidative stress and endothelial dysfunction, all of which impact the TMJ, muscles of mastication and general well-being of the patient.

AC philosophy takes dentistry into the field of medicine and empowers the dentist or physician to treat apnea, hypopnea, upper airway resistance syndrome and snoring and, in doing so, to improve overall health and wellness.

AC TMJ is a new philosophy in dentistry. The airway now trumps everything else in dentistry or medicine. Along with sleep and breathing, the airway is hierarchically the most important function for humans. Ideal health, wellness and brain development depend on an open pharyngeal airway, nasal breathing and restorative sleep. This requires a partnership between the ENT, pulmonologist, lactation consultant, myofunctional therapist,

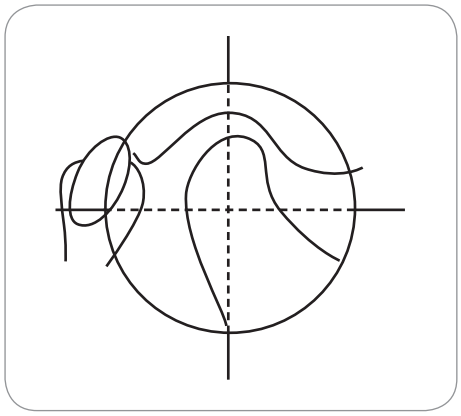

FIGURE 6. New centric relation anterior-superior prosthodontic.

obstetrician/gynecologist, osteopath, chiropractor and physical therapist.

The AC Bite, Balance, Breathing system recognizes these components and builds on the Gelb 4/7 position to establish an AC treatment philosophy so that dentists can recognize, diagnose and treat airway, breathing and sleep disorders to increase oxygenation and improve sleep architecture.

The AC team is an interdisciplinary collaboration of practitioners who integrate the airway, TMJ, masticatory and cervical muscles and teeth with growth and development as well as brain development,[6] cardiovascular health, and treatment of diabetes, obesity and other chronic disease.

The airway includes the nasal airway, tonsils, adenoids, tongue, soft palate, uvula and lingual tonsil down to the epiglottis. Airway resistance and blockage have been associated with oxidative stress, systemic inflammation, intermittent hypoxia and endothelial dysfunction.

Phylogeny, Ontogeny and Animal Models of the Airway

Todd Morgan, DMD, and John Remmers, MD,[8] shed light on the origins of air breathing from the lungfish to modern amphibia up to mammals, where we see the appearance of a diaphragm. The single oropharynx of the amphibian is transformed into three cavities: the nasal cavity, the oral cavity and the

FIGURE 7. NYU appliance.

pharynx in reptiles and mammals. The soft palate becomes more developed in mammals as it separates the nasal cavity from the oral cavity and pharynx. The epiglottis appears with the evolution of the mammalian pharynx.[10] The hyoid and larynx migrate downward and the airway above the epiglottis becomes angulated during mammalian evolution. With suckling or breast-feeding in humans, the epiglottis mechanically locks in with the soft palate to allow simultaneous sucking, swallowing and nasal breathing. The overlap of the soft palate and epiglottis is unique to all suckling mammals, except humans, where the epiglottis descends between six months and 1 year of age.

Morgan and Remmers[8] ask the question, "Walking, talking and breathing: what is the problem?" Our evolutionary pressures to be bipedal and speak influenced the development of the pharynx. Our success as Homo sapiens depended on our intellectual advancement; with the development of the brain came our ability to walk and stand upright and our speech and articulation.[45] These three factors had major effects on our pharynx and ability to breathe while asleep. With the possible exception of the English bulldog, obstructive sleep apnea (OSA) is a uniquely human disease.

The length and flexibility of the pharynx required for human speech is what leaves it vulnerable to collapse while we are asleep. The vast neural network and mechanoreceptors, which protect the airway during wakefulness, seen as increased activity of the genioglossus muscle, is lost during SDB. Morgan[8] speculates, "Three features of the pharynx allowed walking and talking but severely limited the ability to breathe during sleep. These are:

1. Severely angulated airflow path because of upright posture.
2. Lack of epiglottal lock because of epiglottis descent and laryngeal length.
3. Free-floating hyoid and loss of hyoidal strutting. In all other mammalian species, the hyoid is firmly attached to the laryngeal skeleton. The descent of the hyoid from the mandibular plane predisposes for OSA."

One of the most important changes in human primates is the shortening of the horizontal oral length and the relative lengthening of the vertical pharyngeal height. This change has a major impact on the AC TMJ and occlusal philosophy, as the maxilla has moved retrusively through evolution and epigenetic factors.[46-48]

Changes in the Maxilla – the Key

As humans evolved to an upright posture, the larynx descended,[49] the forebrain grew and the facial framework retreated as the nasal airway became diminished in size and function. This is one reason humans do not have the olfactory ability of other mammals. As the cranial base angle flexed, the maxilla was compressed and the paranasal sinus size was reduced, creating millions of sinus sufferers, as well as other facial changes.

The flattened maxilla and longer face are a relatively recent human phenomenon, which differentiates us from primates. The decrease in nose volume associated with cranial base flexing may have increased high upper airway resistance and potential for collapse

further down in the oropharynx. Humans were no longer obligate nose breathers, and with increased demands, mouth breathing was born. This trend of mouth breathing, downward migration of the tongue base and descent of the hyoid is associated with changes in mandibular posture to retrognathic. The increase in mouth breathing is also associated with less time spent with the tongue to the palate, narrowing of the maxilla and increased facial height.[50] The downward and backward rotation of the maxilla and mandible is a powerful predictor of SDB[51] as well as TMJ and malocclusion. A variety of researchers, clinicians and anthropologists has identified an underdeveloped maxilla as the root cause of malocclusion and naso-oropharyngeal constriction. Identification of mouth breathing is therefore recommended as early as the first year of life.[52]

The animal model of OSA is the English bulldog that suffers from brachiocephalic syndrome. Since the 1950s the bulldog has been bred with a thicker neck and pushed-in snout. This brachiocephalic "retropositioning" results in a retruded maxilla and mandible similar to the description of human evolution above. This bony malformation reduces oral volume and pharyngeal space. The bulldog often exhibits pseudo class-three occlusion, crowded teeth, pinched nostrils and a large tongue that protrudes from the mouth. Most bulldogs expire from heart disease or cancer secondary to the effects of brachiocephalic airway narrowing and subsequent systemic inflammation, oxidative stress and hypoxia.[53]

Egil Harvold, DDS,[54] converted rhesus monkeys to mouth breathers by obstructing nasal breathing and observed increased face height, posterior rotation of the mandible and malocclusion. In growing animals in which the nasal airway is gradually occluded there is an adverse effect on the size of the nasomaxillary complex, mandible and pharyngeal air space.[10] The same changes are seen in children who display habitual mouth breathing and who are at risk of SDB. Harvold[54] stated, "Elimination of nasal airway interferences followed by changes from oral to nasal respiration may result in improvement of certain aspects of facial and dental deviations."

A key aspect of the AC TMJ occlusal philosophy is, therefore, establishment of nasal breathing with ideal development of the maxilla.

> The downward and backward rotation of the maxilla and mandible is a powerful predictor of SDB as well as TMJ and malocclusion.

AC in Children

Pediatric sleep disorders result in disrupted, inefficient and inadequate sleep and may affect brain development and cause neuronal damage.[1,6] Even habitual snoring is an indicator of a number of health problems in children, including poor physical growth, emotional and behavioral problems, neurocognitive impairment and decreased academic performance.[55]

It is accepted that an apnea–hypopnea index (AHI) greater than 1 is abnormal in a child. Nasal airway obstruction is particularly significant in infants and young children who are obligate nose breathers. Many premature infants are born with high narrow palates and are mouth breathers from birth.[10] These children also display orofacial hypotonia and secondary changes in maxillomandibular growth. Other children develop difficulty with nasal breathing when tonsils and adenoids develop between ages 2 and 8, which leads to chronic mouth breathing and SDB. Parents may report noisy breathing in infants rather than frank snoring.[52] Bonuck found habitual snoring in 9.6 percent to 21.2 percent of children six months to 6.75 years of age. At age 6, 27 percent were habitual mouth breathers. Snoring increased significantly between 1.5 and 2.5 years in a study of 11,000 children older than 6 years. SDB causes abnormal oxygen and CO_2 levels, interferes with restorative sleep and disrupts cellular and chemical homeostasis. The fragmentation of stage-three restorative slow-wave brain activity by disruptive sleep or hypoxia can result in issues with decision-making, ambition and emotional regulation.[56]

The AC TMJ philosophy starts prenatally with the mother's nutrition and airway. Our goal is for a full-term pregnancy with ideal development of the palate and maxilla. At birth, we advocate for at least two months of breast-feeding,[57] and preferably six months or a year if practical. This confers a reduction in SDB. A poor suck may result from hypotonia from birth and result in SDB.

Frenum attachments may need to be surgically released if they interfere with tongue movement or breast-feeding. Nasal breathing is of paramount importance for growth and development. If a child has nasal obstruction due to allergy, it must be addressed as early as possible.

Many premature infants are born with high narrow maxillas, which predispose them to mouth breathing, the first sign of an airway disorder. With mouth breathing, the tongue cannot assume proper rest posture against the premaxilla, resulting in

narrow, constricted, high-vaulted palates and poor maxillary growth. It can also result in a poorly developed nasal airway, increased facial height, a retrognathic mandible, shorter maxilla and mandible, larger tongue, longer and thicker soft palate and an inferiorly placed hyoid bone.

Tonsils and adenoids tend to hypertrophy between ages 2 and 8; however, before that, by six, 18 and 30 months of age, snoring and sleep apnea are already present, which predict neurobehavioral disorders at age 4 and 7. Children in one study who were symptomatic in infancy were 20 to 60 percent more apt to exhibit neurobehavioral disorders by age 4, and 40 to 100 percent more likely by age 7. Symptoms included hyperactivity, misconduct and peer difficulties. These attention and executive function deficits persisted into adulthood.[58]

Early SDB may lead to permanent prefrontal cortex change, causing attention and executive function problems even if the SDB improves. In other words, SDB's effects may be irreversible.[6]

Our knowledge of brain changes encourages intervention as early as the first year of age. The trend today is adenotonsillectomy (AT), palatal expansion and myofunctional therapy as early as age 3.5. AT resolved only 51 percent of OSA in nonobese prepubertal children.[1] Children who snore in early childhood tend to have lower academic performance independent of AT later in development.[10] History of either SDB or behavioral sleep problems in the first five years led to increased likelihood of special educational need at age 8 in one study.[59]

The maxilla can be developed very early in childhood and has a huge impact on improving nasal breathing and SDB. In adults with narrow palates, adequate nasal breathing is often impossible even with nasal surgery.

Narrow maxillas also predispose to TMJ disorders, growth abnormalities and SDB. Sixty percent of facial growth is attained by age 6 and 90 percent by age 11 or 12; therefore, early intervention is particularly warranted in children with SDB. Occupational therapy and myofunctional therapy with special orofacial exercises during feeding and chewing in the first two years of life may lead to improvement in facial anatomy, repositioning of the tongue and development of a normal nasomaxillary complex and mandible.[10]

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It is encouraging to realize that early interdisciplinary intervention may prevent SDB and subsequent pathologic sequelae.

Development of the Maxilla

Epigenetic factors are thought to have dramatically changed the development of the jaws.[5,7] Robert Corrucini, PhD, has also attributed crowded teeth and small, narrow jaws to the soft consistency of the diet. Kevin Boyd, DDS, a pediatric dentist, points to the dietary changes following the industrial revolution and lack of breast-feeding as a cause for the shrinkage of the maxilla.[7]

Seminal work by Weston Price, DDS, has demonstrated that malocclusion occurred in primitive tribes within two generations of the introduction of an industrialized diet.[60]

Most jaws today do not have room for all 32 teeth, as evidenced by the number of children and young adults who require wisdom teeth extractions. Comparing the wide U-shaped skulls from the Smithsonian and the Museum of Natural History with today's skulls indicates that the maxilla has significantly retruded.

Epigenetic factors include environmental pollutants, obesogens, sugar in our diet and pesticides. These factors are also thought to have caused the sudden dramatic increase in attention deficit hyperactive disorder (ADHD), obesity, diabetes, heart disease and a spectrum of other disorders.

Abnormal nasomaxillary growth is thought to be responsible for SDB and TMD. AC philosophy addresses the following vital pathologic processes:

- Oxidative stress — results in free radical production.
- Systemic inflammation — associated with the release of inflammatory cytokines, tumor necrosis factor alpha (TNF-alpha), interleukin 6 (IL6).
- Intermittent hypoxia — oxygen desaturation is followed by reperfusion, often hundreds of times per night.
- Endothelial dysfunction — reflects the health of the blood vessel wall and the ability to vasodilate. It is the risk factor of risk factors for cardiovascular disease.
- Autonomic deregulation — thought to be a major contributing factor in the development of cancer and cardiovascular disease.

Lack of quality sleep increases pain and lowers immune function while increasing TNF-alpha, IL6 and interleukin 8 (IL8).[61]

Most chronic diseases are greatly influenced by the airway and breathing. Opening the airway with the AC TMJ philosophy allows normalization of endothelial dysfunction and reduces oxidative stress, systemic inflammation and intermittent hypoxia. This is often

the missing link for the treatment of fatigue, obesity, ADHD, diabetes and cardiovascular disease.

AC treatment will help determine the final TMJ, muscle and occlusal position. The TMJ will be decompressed and the pharyngeal airway will be open.

Nighttime Philosophy

Therapeutic jaw position at night is dictated by the airway first and TMJ second. Because bruxism is associated with brain arousal and is thought to be related to SDB, a sleep study is required for any patient with excessive daytime sleepiness (EDS), snoring, witnessed apnea, high blood pressure (HBP) or narrowed airway. Home sleep studies or PSG are both adequate, depending on comorbidities and the information required.

A positive sleep study will usually necessitate an oral appliance to maintain an open airway, sometimes combined with continuous positive airway pressure (CPAP), nasal surgery and positional therapy. Treatment duration could be three to six months followed by a sleep study to ensure efficacy.

Bite changes can be expected, particularly for patients with class-two division-two malocclusions or retruded maxillas. At a three-week follow-up visit, the dentist monitors the list of chief complaints related to pain and dysfunction. Criteria for success require alleviation of pain and dysfunction complaints as well as of EDS, noisy breathing and OSA.

Daytime Philosophy

Oral appliances are often used during the day as well to address daytime complaints, which require habit control and TMJ or muscle rehabilitation, particularly for patients who need cognitive behavioral therapy. Many patients who present with SDB also have headache and dysfunction related to growth and development, parafunction or past trauma. In patients who present with TMD, pain or dysfunction, the appropriate appliance design is chosen in combination with physical therapy, medication, Botox injections, craniosacral therapy, chiropractic or osteopathic manipulation. Lower appliances are preferred during the day to help articulation. The NYU and lower stabilization appliances are recommended for six to 12 weeks of daytime wear and then as needed during physically and emotionally stressed periods. These might include exercising, playing competitive sports, studying for and taking tests, and putting in intense days at work.

> Our philosophy is to decompress the jaw joints bilaterally by anterior repositioning of the mandible.

Vertical Dimension

Most patients have lost vertical dimension or have compressed temporomandibular joints. In long-face patients, we want to decompress the joint without opening vertical more than necessary. In anterior open bites, we always establish anterior guidance by providing anterior contact.

In dental school, we were taught that one could not open the vertical dimension of occlusion. We now know that the body will reestablish freeway space, and often the vertical needs to be added to at night to maintain an open airway.

Anterior Posterior

Epigenetics has predisposed to predominantly retrognathic bites with forward head posture. As we reposition the mandible forward, we work with physical therapists who use the Alexander Technique, Feldenkrais Method, Pilates and Gyrotonics to strengthen the core and achieve ideal posture, like that of a dancer or actor.

As we bring the jaw forward, the head goes back over the shoulders. Our philosophy is to decompress the jaw joints bilaterally by anterior repositioning of the mandible. Criteria for repositioning include recapturing the disk when possible, alleviating joint noise when possible, achieving ideal facial esthetics, maintaining minimal bite opening during the day and maintaining natural anterior guidance when possible.

I tell my patients that I am putting their chins back to the middle of their faces. When phonetics and ramus height discrepancy support moving the mandible back to the center while alleviating joint compression and reducing joint noise, it is done. The mandible often migrates to the short ramus side, which is the high eye side.

Beauty

Nonsurgical facelifts were talked about in the ’80s and ’90s. Today we are able to restore full lips and reduce nasolabial folds, but more important, increase the oxygenation of the skin and open the eyes. There is a glow and sense of life that was missing. Part of the transformation is the reduction in pain and stress on the body. More important perhaps is the healing effect of restorative sleep, decreased inflammation, hypoxia and oxidative stress.

In approximately 10 percent of adult cases and 100 percent of children’s cases, orthodontics, such as palatal

expansion, is required. Smile lifts, as popularized by Larry Rosenthal, DDS, from NYU and Aesthetic Advantage, are often needed because of the preponderance of narrow maxillas. Dr. Rosenthal and I have restored several cases after TMJ and AC stabilization.

Occlusal Philosophy

Many patients have anterior open bites secondary to condylar degeneration or perimenopausal changes in the joint. In those cases, we always establish anterior guidance, typically bringing the mandible forward to decompress the joint and open the airway. Whenever possible, the appliance establishes canine guidance. I use a modified Gelb appliance for daytime, covering the cuspids and placing acrylic behind the lower anterior teeth to prevent shifting.

Gnathologic principles can be used if the jaw is in the right position.

Slight posterior open bites are acceptable and often preferred. We want the majority of force in the premolars and anterior teeth. A slight posterior open bite discourages parafunction.

In 10 percent of cases, some form of dentistry is required following my treatment plan, which often involves physical therapy, trigger point injections and Botox injections.

Criteria for Success

Airway

- Open day and night.
- Improved SDB or AHI; respiratory disturbance index (RDI) decreased by at least 50 percent.
- Improved EDS.
- Nasal breathing.

Posture (standing, seated and supine)

- String pulling up the back of the head with slight flexion.
- Normal spinal curvature achieved with Alexander Technique, Feldenkrais Method, Pilates, yoga.
- Lips together, teeth apart.
- Chest up.
- Belly in, engage abdominals.

TMJ

- Absence of clicking, popping, locking.
- Decompressed in the range concentric to Gelb 4/7.
- Full range of motion or a measured opening of 36-54 mm.

Face

- Shape — favors horizontal growth.
- Lips — full and symmetrical.
- Skin tone — glowing.
- Eyes — open and alive, not showing too much sclera.
- Profile — good vertical and strong lower jaw.

Teeth

- Smile lift or palatal expansion to fill buccal corridors.
- Support airway and TMJ.
- Cuspid rise.
- Anterior coupling.
- OK to have lighter contact posteriorly or slight posterior open bite.

Conclusion

A small upper airway and stunted nasomaxillary complex predispose humans to SDB.[8] Early intervention is essential to prevent and correct anatomic abnormalities, which will also prevent SDB and resultant emotional and behavioral problems, neurocognitive impairment, decreased academic performance and poor physical growth. SDB has also been associated with hypoxia, oxidative stress, disrupted sleep and endothelial dysfunction,[62] all precursors to obesity, cardiovascular disease and diabetes.

Upper airway resistance and SDB are also linked to a retruded short maxilla and retrognathic mandible, which predispose to TMD headache and cervical postural change.

The Airway Centric TMJ and occlusal philosophy will result in a condylar position between concentric and Gelb 4/7 during the day and Gelb 4/7 to the middle of the eminence at night.

Robert M. Ricketts, DDS, stated, "Respiration and mastication are biologically inseparable. It would appear that normal nasal breathing is conducive to normal growth of the maxilla and normal development of the occlusion of the teeth."[63] The influence of gnathology and orthodontics in the '30s and '40s led to the concept of treating just the teeth instead of the face or the patient as a whole.

Ricketts also wrote, "We talk about the oral cavity as if it is independent of the development of the first branchial arch and independent from respiration. Biologically, the functions of mastication and respiration have been connected with the same set of muscles and the same set of nerve paths. We can't separate them."[63]

Final occlusal restorations cannot be completed until SDB is successfully managed over a six-month to one-year period. There will be occlusal changes based upon the initial position of the nasomaxillary complex, mandible, pharyngeal air space, hyoid bone and craniofacial morphology.

The dentist should recognize and address TMJ and airway disorders prior to restorative dentistry, as TMJ and airway treatment may result in occlusal changes. ■

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Other Authors' Critiques of Dr. Gelb's Paper

Dr. Fricton

Dr. Gelb's Airway Centric TMJ Strategy is based on innovative research suggesting that the maintenance of an open airway is a critical factor in patients who have TMD. With a narrowed airway, changes in occlusion and facial morphology compensate for the need to maintain an open airway.

Management of patients with TMD thus needs to consider the airway, sleep-disordered breathing and related neurobehavioral disorders. The paper presents broader innovative outcome criteria to consider in managing TMD that include not only the teeth, occlusion and TMJ but also the airway, posture of the tongue, head and neck and facial esthetic features.

Editor's note: See Dr. Fricton's general comments and conclusion on page 545.

Dr. Simmons

Dr. Gelb's manuscript is an excellent review of the relationship between TMDs and sleep-disorder breathing (SDB). His thought process involves evaluating patients who needs TMD care for SDB. This is an appropriate process.

The term temporomandibular disorders should be used only as a general statement to describe all disorders that can afflict the temporomandibular complex. TMDs include all TMJ internal derangement disorders, arthritic disorders and fractures and all associated structure muscle disorders, nerve disorders, vascular disorders, neoplasms and genetic disorders. Specific disorders of the TMD complex should be referenced when treatment methods are described.[1]

Intracapsular TMDs are usually not preventable because most are a result of TMJ articular disk displacement secondary to ligament injury. The orthopedic medicine community clearly believes that acute macrotrauma is the cause of most ligament injuries.[2] Acute macrotrauma may not be preventable.

Dental occlusion is driven by many factors, among which are genetics, the tongue, the cheek muscles, dental diseases and the airway.

TMJ/TMD research measures appropriate variables,[3] such as range of motion, pain upon anatomic site palpation, etc., but it is also appropriate to measure SDB variables in this patient population.

Slight posterior open bites are an acceptable result of reversible anterior repositioning appliance care but should be closed by either a long-term appliance, orthodontics or other restorative method.[3,4] The reviewing author does not believe that most dentists would prefer a posterior open bite occlusion or that this status of occlusion discourages parafunction.

Not all TMD patients need airway care. A significant number of TMJ internal derangement patients have airway issues and need care for this disorder. The treatment concepts presented in this manuscript are valid.

I would like to thank Dr. Gelb for participating in this journalistic endeavor. His patients appreciate his care in relieving their pain and dysfunction and their airway needs.

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CONTINUES IN SIDEBAR ON 561

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OTHER AUTHORS' CRITIQUES, CONTINUED FROM 560

Dr. Raman

Drs. Fricton, Gelb and Simmons' well-written papers contribute to the knowledge base for dentists.

Dr. Gelb nicely summarizes the history of TMD treatment approaches. His Airway Centric approach is very congruent with the PNMD approach. TMD treatment guided by objective physiologic measurements such as real-time electromyography (EMG) and computerized mandibular scanning (CMS) is the foundation of PNMD. While useful, polysomnography (PSG) doesn't give real-time data for clinical dentists as do EMG and CMS.

Dr. Gelb states that anterior repositioning appliances are superior to neuromuscular (NM) splints. NM orthotics are constructed to a mandibular position where all masticatory and cervical muscles are unstrained. Craniocervical physical therapy to address cervical restrictions and recapture of any displaced disks is done before taking PNMD bite relation. This position is determined by the real-time physiologic parameters of EMG. The resulting changes to the condylar position vary on an individual case as recorded by CT scans. Often it is down and forward in the fossa. It can also be more downward on one joint. So his claim that an arbitrary anterior positioning of the mandible is more efficacious than a physiologic NM orthotic appliance is illogical. The referenced studies seem to compare flat plane appliances.

Dr. Gelb describes moving the mandible back to the center using phonetics and ramus height. Is this any less subjective than "romancing the mandible"? While acknowledging the utility of clinical judgment and subjective factors such as phonetics, EMG of muscles of mandibular and cervical posture gives real-time objective data on the physiology rather than using anatomical landmarks.

I respect the contributions of Dr. Harold Gelb. Dr. Michael Gelb states that the Gelb 4/7 position correlates with the physiologic normal position for the TMJ condyle in the fossa and that the Airway Centric philosophy will result in a condylar position between concentric and Gelb 4/7 during the day and Gelb 4/7 to the middle of the eminence at night. Focusing on the relative position of the condylar head in the fossa to an idealized position within the fossa misses on two counts:

- Morphological changes of the condyles – bending, breaking, flattening and other compensatory changes make the position of such a condyle different from an undamaged condyle within the same fossa.[1]
- Anatomical appearance shows the current condition of the structures that have resulted in response to the forces over time. It is akin to looking at the rearview mirror. Physiologic parameters – such as electrocardiogram (EKG), apnea–hypopnea index (AHI) and EMG give current data on the function of the organism. Function changes the form just as oral breathing changes maxillary shape.

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Dr. Gelb's Response to Critiques

Response to Dr. Fricton's critique

Dr. Fricton introduces the dental community to a human systems approach for chronic pain and temporomandibular disorders. I would like to thank Dr. Fricton for a novel and thought-provoking manuscript.

Response to Dr. Simmons' critique

I would like to thank Dr. Simmons for an excellent manuscript. In those TMJ patients who do not have resistive breathing or sleep disordered breathing, I would follow Dr. Simmons' TMJ philosophy.

We both treat to the Gelb 4/7 position and finish our cases orthodontically and restoratively. I may wean a larger percentage of patients off daytime appliance wear except for stressful periods such as midterms and finals and be content with a posterior open bite as long as chewing is not an issue.

Response to Dr. Raman's critique

I agree that Airway Centric (AC) TMJ philosophy is often congruent with a neuromuscular (NM) approach, as both open the airway and relatively decompress the joint.

Following six months to one year of AC appliance therapy, the mandible will usually reach a stable and repeatable down and forward position during the day with the appliance out. This position is taken only after a polysomnogram or home sleep test has confirmed successful treatment of sleep disordered breathing.

The NM approach does not ensure successful TMJ or airway management. It measures electromyography (EMG) and computer mandibular scanning. Some AC dentists measure real-time heart rate variability (HRV) to fine-tune appliance and jaw position.

AC moves beyond Gelb 4/7 condyle repositioning therapy by placing an open airway hierarchically at the top of the pyramid.

Final treatment position should optimize HRV, EMG and resonant frequency breathing. Final treatment position maximizes oxygen saturation, stage three and REM sleep and manages the apnea–hypopnea index (AHI), respiratory disturbance index (RDI) and sleep fragmentation and arousals.