Introducing the **Advanced Light Force** (ALF) Appliance

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ABSTRACT
The use of a light-force oral mechanism to facilitate orofacial reorganization and optimize oral-motor function.

INTRODUCTION

This orofacial reorganization and optimized oral-motor function also allows for an enhanced genetic expression in cranial facial growth and development. Challenges to orofacial form and function have captured the attention and resources of the dental profession for decades. In 1982, the quest for more effective, lightweight interventions aligned with osteopaths' focus on cranial rhythm and movement; Dr. Darick Nordstrom developed the Advanced Light Force (ALF) appliance.[1]This novel approach to orthodontic systems works to integrate cranial mobility with palate, tooth, and jaw alignment, thereby promoting better swallowing, breathing, speech and sleep. By focusing on the form and function of the neuro- and viscera-cranium, the gentle action of the ALF appliance provides a safe sensory stimulus within the mouth that allows for a greater range of neurological regulation to occur, especially through the cranial nerves and the autonomic nervous system. Thus patients wearing the ALF appliance experienced far-reaching changes in bite, body, brain, and behavior. As Dr. Nordstrom has noted, "With insertion of the ALF appliance we have seen seemingly unrelated health issues improve or completely resolve."[2] Here we will explore the neurophysiological foundation of oral-motor function to see how such a subtle ALF device can facilitate such profound realignment.

EMBRYOLOGIC DEVELOPMENT

The story of the dental and craniofacial structures that dentists observe in their patients begins during the embryological process. By four weeks' gestation, the ectodermal brain tube is following the stimulation of new neural crest cells to organize the genetically-driven primordial orofacial cells and structures.[3] Neural crest cells that will become sensory cranial nerves migrate into their pharyngeal pouches, where cells for the mandible and maxilla are organizing to sprout. Neural crest cells also migrate forward to guide the formation of the fronto-nasal prominences and the palatal shelves. These future orofacial bones are assembling to form the scaffolding for the proliferation of brain structures as well as the organization of the meso-endodermal oropharyngeal structures. In normal embryological development, the palate forms from three shelves. An anterior primary palate, that emerges from the frontonasal process, and two laterally placed secondary palatal plates that are outgrowths of the maxillary prominences.[4] These two secondary palatal plates are originally vertically oriented, alongside the growing tongue. At the seventh week of gestation, they pivot to their horizontal orientation and fuse both forward to the anterior plate, as well as medially with each other. At that point, the tongue should continue its downward and forward progression within the mandibular frame.[5] The exact process of tongue morphogenesis from neural crest cells and paraxial mesoderm is not well understood,[6] but it appears that the program directing tongue myogenesis is more similar to axial muscles (limb and diaphragm) than to mastication muscles (temporalis and masseter).[7]

The fusion of the palatal shelves is a complex process, both within its own sutural signaling and in coordination with tongue dynamics (failure of palatal fusion manifests as cleft palate.) The palatal shelf elevation and fusion process reflects the importance of craniofacial movement in triggering proper neurological response.

Stated another way, the fusion process is an exquisite dance of motion that signals the nerves to connect to the target tissues. This two-way signaling affects the proper dynamic formation of our craniofacial structures, and as we will see, informs us of the potential to introduce a subtle mechanical input that will prompt a restorative neurological output.[8]

GENETIC MISHAPS

During the dynamic period of embryological development, all of the structural organization just described is driven by genetic expression. A wide range of transcription factors, enzymes, proteins, and adhesion molecules prompt the migration and specialization of the neural crest cells. However these craniofacial pathways are highly vulnerable to genetic mutations.[9] Although over a dozen different genes are being studied for their role in these disturbances,[10] there are two genetic mutations that are especially frequently implicated. The first involves the MTHFR (methylenetetrahydrofolatereductase) enzyme produced by the MTHFR gene; variations in the gene disrupt proper methylation, and alter transcription of DNA, affecting proper neurotransmitter function during palatogenesis,[10] MTHFR gene disuptions also block folate metabolism, which disturbs normal cell development and can cause neural tube defects. A second common genetic mutation involves the TBX22 gene, which regulates downstream genetic behavior in forming nasal, palatal, pharyngeal, and tongue structures.[9,10,11]

The most common genetic mishaps that dentists see in practice include high palate and ankyloglossia (tongue-tie), which set the stage for compromised airway function (leading to sleep dysregulation), as well as impaired oral-motor functions of suck, swallow, and breathing. Ankyloglossia is an X-driven congenital anomaly with a four percent prevalence expressed more often in males[12], characterized by an abnormally short lingual frenum. It may also involve a highly attached genioglossus muscle.[13] The TBX22 gene mutation that give rise to ankyloglossia also produces a high arched palate (possibly reflecting a submucosal cleft palate due to poor osteogenesis); and a deformed vomer. The latter, may lead to choanal atresia and a persistent oronasal membrane, which restricts nasal breathing.[14] These factors combined can manifest as a restricted nasopharyngeal passageway and aberrant buccopharyngeal dynamics, including enlarged tonsils and adenoids and an amplified gag reflex.

Although genetic aberrations may be the underlying cause of craniofacial and oral deformities, they don't only disrupt proper alignment of teeth and jaw function. They can also impair neuro-hormonal function, autonomic nervous system regulation, and brain and body sensory motor functions, because dynamically and functionally, the back of the throat is the front of the brainstem. Every bite brings a message to the brain. The sensory input from the entire face and mouth is received in the trigeminal sensory nucleus, which then coordinates interpretation of the incoming signals with other brainstem nuclei, generating a motor output through motor cranial nerves. Stated another way orofacial movement is its own form of sensory input to the brainstem, where it is cross-referenced with previous interpretations to make output patterns. Genetic disruptions that result in malformed craniofacial structures that don't move properly also impair this cranial nerve dialogue. Fetal or neonatal traumas can plasticize the brainstem circuits to interpret every critical survival function (suck, swallow, breath, heartbeat, digestion) as confusion or even danger.

PRIMITIVE REFLEXES

Craniofacial dysfunction is the reflection of brainstem and cranial nerve disorganization and a disrupted "set point"of the Autonomic Nervous System circuits. Normally, we are already wired at birth to maintain our internal homeostasis via the parasympathetic system, even as we face our external environment via the sympathetic system. Our primitive reflexes (for suck, swallow, rooting, grasping, and gazing) are built to serve our survival in this regard. These brainstem-mediated, automatic movements begin by gestation week 26, and are fully present at birth in full-term infants.[15] The primitive reflex responses are meant to be suppressed, or "integrated" when higher-order, conscious neural functions can take over management of those activities. As the infant "settles in" and creates sensory input patterns (olfaction, vision, taste, sound) from the familiar environment, and internal functions become more reliable, and social engagement and communication can grow. However, in cases of premature birth or neurological impairment, primitive reflexes may be absent, weak, or dysregulated and, therefore, persistent. Life-saving measures such as ventilation also may interfere with proper expression of critical reflexes, especially sucking and the Moroeflex.[16] Children who later display challenges with sensory processing, gross or fine motor delays, central coordination disorder[16] or behavioral issues may be experienced with the persistence of these non-integrated primitive reflexes. In essence, the retained primitive reflexes block the higher-order central nervous system processing that is necessary for the full internal homeostatic function that allows for normal engagement in home, school, and the work environments.

NEUROBIOLOGICAL CONNECTIVITY AND BIOTENSEGRITY

Neuroscience research is just beginning to examine the underlying neurobiological connectivity issues that may be at the root of these challenges.[17] If behaviors such as hyperactivity, poor attention or emotional regulation, sensory processing, gut dysfunction, balance and motor control, sleep disorders, or even bedwetting[18] might be a reflection of underlying neurobiological issues that relate back to original central and autonomic nervous system wiring and function, is it possible to gently provide an alternative oral input that in turn allows a novel, organizing output to occur from brain to bite, body, and behavior? Clues to answering this question can be found by examining oral-motor development and function, the universal law of design concerned with balancing forces and tension is Tensegrity.[19] Restoration of the balances of stress and tension in the cranio-mandibular system through the scaffolding effect of the Advanced Light Force (ALF) appliance on the palate follows the principals of engineering design called "Tensegrity", discovered by Richard Buckminister Fuller. This balancing of the forces of stress and tension in the human body has been termed "Biotensegrity".[20] "Research into biotensegrity has now established that prestressed tensegrity cells, linked hierarchically to their extracellular environment and to their nucleus, receive mechanical signals (termed mechanotransduction) and integrate them with other biochemical signals to produce an orchestrated cellular response. It is evident that cells function as biotensegrity structures that are able to receive mechanical signals and integrate those signals with other biochemical signals to modulate second messenger signaling and gene expression".[20] In 1983, Ingber wrote in a letter to Buckminster Fuller, "the architectural form of a tissue may itself serve to coordinate and regulate the shape, orientation, and growth of individual cells through transmission of the physical forces of tension and compression characteristic of a given three dimensional configuration."[21] Fetal development of orofacial bones relies on this interplay between force, tension, and function. To regulate osteogenesis, an ossifying bone needs a mechanical input, provided by meeting the sutural edge of another bone, and feeling that push-back. This kind of "mechanical stress modulation" promotes skeletal modeling of bones and cartilage.[10] Post-natal, what kind of mechanical stress modulation might facilitate restorative modeling of the oral cavity? Studies in growing rats involving orthodontic wire expansion have showed that "secondary cartilage can undergo chondrogenic and osteogenic differentiation in the maxillary arch,[8] meaning that a mechanical stimulus in the natural growth cycle facilitates reorganization in bone and cartilage. Can the subtle input of the ALF wire stimulate orofacial reorganization? If the bones resume their innate growth process, then the neurosensory conversation with brainstem and cranial nerve circuits can reorganize as well. Moreover, when brainstem and cranial nerve circuits find ease of function in one specific route, that ease down regulates sympathetic output, and clears a path for other circuits to down regulate as well. As brainstem circuits clear and cortical connectivity is able to organize, delayed reflexes can be integrated and cortical neural integration can proceed.

MECHANICAL STIMULI FOR CRANIOFACIAL DEVELOPMENT

In normal orofacial development, proper infant suckling begins the stimulation process for both oral-motor and neural organization. Proper sucking requires coordination of the anterior tongue, which latches on to initiate the vacuum extraction of breast milk, and then rolls to posterior tongue depression,[22,23] which leads to swallowing (while coordinating breathing for a safe O2 saturation level). This is a critical first step in affirming the input-output regulation of the cranial nerves that govern suck, swallow, and eventually mastication. An infantile swallow that is not well organized, can deter the neurosensory and motor function of the entire orofacial complex. The tone and function of the orbicularis oris, the buccinators, the masseters, and oropharyngeal muscles, (including the tongue), may not develop properly, which may lead to a poor transition to mastication (as well as speech and breathing issues). The transition from breastfeeding to solid and semisolid foods is instrumental in ensuring proper development of the bones, muscles, and teeth. Whereas soft foods require little or no masticatory force, relying instead on mashing and swallowing that involve a straight up-and-down motion of the jaws with little or no force. The introduction of solid and semi-solid foods, initiates the activation of the masticatory cycle. The vigorous grinding and tearing motions that characterize mastication provide the mechanical stimulus for bones and teeth. Specifically, this masticatory cycle transmits through the teeth (which are tiny organs full of proprioceptors) and the periodontal ligaments (more proprioceptors), signaling the necessary osteogenesis for jaw development.[24] This stimulation is essential for the proper size and shaping of the jaws, whereas poor mastication dynamics fail to provide the necessary mechanical stimulus for proper craniofacial bone growth. An indication of normal transverse bone development in the jaws is the emergence of diastemas (spaces) forming between the teeth by age four.[25]

THE ROLE OF THE ALF

Dr. Dennis Strokon and Dr. Gavin James have written numerous articles on the use of the ALF appliance in the treatment and correction of cranial strain patterns, torsions, side bend lesions, superior and inferior vertical strain patterns and other problems.[26,27,28] If proper mastication dynamics

are not occurring, and craniofacial development becomes distorted, the insertion of an ALF appliance may provide the critical sensory input that is needed to promote neurosensory organization. As we have seen, every bite sends a message to the brainstem, which sends a formative output back to the oral structures. Thus, the delicate sensory input provided by the ALF can alter osteogenesis, addressing and relieving cranial strain patterns[1] and promote proper transverse development of the jaws. As cranial nerve sensory input changes, and spontaneous corrective motor output follows, autonomic and neuro-hormonal brainstem circuits can reorganize as well. Rebalancing of the parasympathetic and sympathetic drives promotes calmer internal function, less sensory defensiveness, and better attention to conscious processes. This in turn, can set the stage for cognitive engagement with corrective tongue exercises. The combination of myofunctional training exercises with the ALF can facilitate proper tongue placement for swallowing and movement of the teeth, setting in motion, neurological feedback loops that prompt more effective management of oral-motor function. The ALF stimulates transverse bone growth, in much the same way as the chewing of solid and semi-solid foods in the developing child. Through its gentle and subtle pressure to the tooth organs, the ALF exerts a lateral force 24 hours a day and seven days a week. The tooth proprioceptors and periodontal fibers interpret this lateral force as sensory input similar to chewing, input that in children spurs the creation of space for the developing dentition through appositional bone and cartilage growth in adults, this occurs through appositional growth.[29] Although the standard ALF touches only four teeth, it promotes spaces between all the teeth. The design and placement of the anterior and posterior omega loops encourages the tongue to assume the correct oral rest posture position, and to participate in the transverse and antero-posterior forces necessary to stimulate growth and positioning of the maxilla for the development of a palate of proper size and shape.[3] In essence, the ALF is functioning like a surrogate or biomimetic tongue giving stability to the cranio-facial complex similar to a scaffolding in the palate, (restoring biotensegrity to the cranial-mandibular system). It functions as a neurophysiologic stimulus, as an orthopedic/orthodontic device, and it encourages the tongue to assume a more normal rest posture position. The palate lies in close proximity to the brainstem and directly beneath the sella turcica, which houses the pituitary gland. This highly innervated palatal area, coupled with the proprioceptors in the tooth organs and the periodontal ligaments transmit a subtle stimulatory input not only to the roof of the mouth, but also to the brainstem and the endocrine system. More specifically, the ALF's sensory input to the palate produces a calming effect on the sympathetic nervous system, much like the effects of a pacifier[30] in an infant or thumb sucking in a young child. The benefit of this tranquilizing effect is that it allows the brainstem to refocus on issues other than sympathetic protection (survival).

NITRIC OXIDE AND NASAL BREATHING

Dr. Jon Lundberg, a physician in the Department of Physiology and Pharmacology, at the Karolinska Institute in Stockholm, discovered that the paranasal sinuses are powerful producers of nitric oxide (NO). Although this gas is considered a pollutant in the atmosphere, in small doses, it is lethal to bacteria and viruses. Because the sinuses are warm, moist, and bacteria-friendly, theoretically providing perfect places for bacteria to live. Dr. Lundberg believes that NO keeps the sinuses sterile.[31] Other researchers agree that NO production "is important for controlling intracellular bacterial pathogens.[32]

The production of NO is also essential for hormonal and growth regulation and serves a number of other functions, including improves blood flow, lowers blood pressure, limiting the damaging effects of inflammation (c-reactive protein), and limiting tissue damage in disease.[33] NO activates cytosolic guanylatecyclase, elevating intracellular levels of cyclic GMP (cGMP), which is essential for smooth muscle relaxation and ion transport. NO induced formation of cGMP also is involved in hippocampal long-term potentiation (LTP), a long-lasting enhancement of synaptic transmission efficacy that is considered the basis for some forms of learning and memory.[34] The production of NO in the sinuses may be fundamental in keeping the tonsils and adenoids free of infection, it is contingent upon normal nasal breathing during sleep. From a biomechanical perspective, a high palate and inadequate tongue tone contribute to decreased or absent nasal breathing, especially at night. In a study examining obstructive sleep apnea syndrome (OSAS) in Korean soldiers, researchers found a significantly higher prevalence of "high arched palate, tongue indentation, long uvula, large tonsils and retrognathia (a type of malocclusion) in the high risk OSAS group and concluded that a high arched palate, long uvula or low lying soft palate, and tonsil size III or IV, were independently predictors of OSAS."[35] The calming effect of the ALF on the sympathetic nervous system can influence NO production and, thus, enhance the benefits of adequate NO supply. Specifically, when the ALF helps a child sleep more profoundly, have fewer restless episodes, and achieve better breathing patterns and a more relaxed state, neuronal nitric oxide synthase (nNOS) – the enzyme that triggers the production of nitric oxide increases.[33] In addition, normalization of breathing patterns and other autonomic functions may finally prompt resolution and integration of retained primitive reflexes. This integration can sometimes occur quite rapidly following introduction of the ALF, or it may take place more

slowly over several weeks or months. Resolution of retained brainstem mediated primitive reflexes in turn may lead to a number of dramatic outcomes, including cessation of drooling, thumb-sucking, and bed-wetting; enhanced immune system functioning with a subsequent decrease in allergic incidents and gastrointestinal issues; improved cognitive attention and function, motor coordination, and athletic performance. Others have observed similar symptomatic improvement through neurotherapy development programs[18] and reprogramming through programs of sensory input (e.g. Brain Gym). Furthermore, as the autonomic nervous system regulation continues to improve, hormonal function through the hypothalamic-pituitary-adrenal (HPA) axis also normalizes, which may affect learning and memory function, regulation of fertility, and growth spurts.

CONCLUSION

The subtle sensory input from the ALF provides a safe, consistent 24/7 input that mirrors effective orthopedic, orthodontic, osteopathic, and neurosensory regulation. The therapy allows a return to a normal balanced biotensegrity system in the cranio-mandibuler complex. The ALF's biomimetic effects on the palate encourages proper tongue placement for normalized oral rest posture position, it promotes corrective orofacial form and function. It facilitates both cranial nerve and autonomic circuit regulation, prompting a synthesis of cellular, biochemical, hormonal, neurological, and behavioral organization. From bite to brain to behavior, the ALF promotes optimal form and function with mechanisms supported by science.

Oral Health welcomes this original article.

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