Maldevelopment of the cranio-facial-respiratory complex: A Darwinian perspective

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Abstract

Aim The mammalian Cranio-Facial-Respiratory Complex (CFRC) comprises several different biological tissues that collectively function under coordination from the central nervous and cardiorespiratory systems, primarily to breathe, eat and drink as well as integrating the sensory and motor systems for speech, communication and protective mechanisms. Anthropologists have long recognised that lifelong exposure to modern feeding regimens of readily available and highly processed foods, changes in breastfeeding and weaning, can impact expression of various phenotypic traits affecting the CFRC quite differently than does lifelong exposure to more traditional ancestral feeding regimens, typical of hunter-gather/foraging in non-Western-exposed cultures. The aim of this study is to highlight the role of the paediatric dentist in a multidisciplinary approach in which professionals working in and around the CFRC can actively prevent tooth decay and skeletal-dental malocclusion in the light of evolutionary oral medicine.

Results As a result of changes in the environment, in the food quality, in eating and feeding practices starting from day one, two oral diseases of civilisation, tooth decay and skeletal-dental malocclusion, have both relatively recently reached worldwide epidemic proportions and afflict people of all ages.

Conclusion A multidisciplinary approach in which professionals working in and around the CFRC can actively promote prevention or reversal of dento-skeletal and myofunctional disorders, diagnose them when present and coordinate the appropriate therapy and life long maintenance programme.

KEYWORDS Malocclusion, Dental caries, Lingual frena, Cranio-Facial-Respiratory Complex, Maldevelopment.

Introduction

The mammalian Cranio-Facial-Respiratory Complex (CFRC) comprises several different biological tissues that collectively function under coordination from the central nervous and cardiorespiratory systems, primarily to breathe, eat and drink as well as integrating the sensory and motor systems for speech, communication and protective mechanisms.

Anthropologists have long recognised that lifelong exposure to modern feeding regimens of readily available and highly processed foods, changes in breastfeeding and weaning, can impact expression of various phenotypic traits affecting the CFRC quite differently than does lifelong exposure to more traditional ancestral feeding regimens, typical of hunter-gather/foraging in non-Western-exposed cultures.

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Diseases of civilisation and genomic environmental mismatch

The relatively recent appearance of chronic Western diseases in humans, such as obesity, type 2 diabetes and cardiovascular disease, is not accurately explained as somehow resulting from recent, and therefore anomalous, macro-genomic changes over the past few centuries or so during which prevalence of these and other modern public health maladies have grown to epidemic proportions. A more plausible explanation is likely to be found when evaluating the problem from an evolutionary perspective and using this understanding for the development of research strategies to improve prevention of malocclusion and myofunctional disorders, and to optimise diagnosis and clinical treatments of orofacial structures and functions disorders.

Evolutionary oral medicine/Darwinian dentistry

Evolutionary Medicine (EM) is a new approach providing a useful framework for understanding modern systemic diseases (Nesse, 1991). Evolutionary Oral Medicine (EOM), or Darwinian Dentistry, is a branch of EM whose goals are to understand the evolutionary origins of oral diseases and

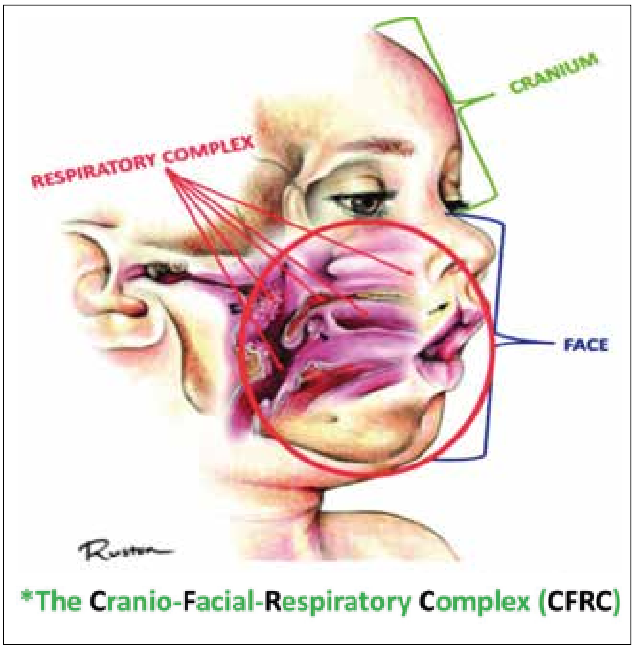

FIG. 1 The interconnected cranio-facial and respiratory complexes [Garg et a., 2017] - Courtesy of: Wolters Kluwer Health, Inc..

to use this understanding for the development of diagnostic, preventive, clinical treatments and research strategies. Worldwide, two oral diseases of civilization (ODC), dental caries (tooth decay) and skeletal-dental malocclusion (SDM)-poorly aligned teeth and jaws, mid-face maldevelopment, etc.-, have both relatively recently reached epidemic proportions and afflict people of all ages.

Similar to obesity, obstructive sleep apnea and type 2 diabetes, ODC seem to follow a predictable pattern of progression.

1) If a susceptible individual is identified early, ODC can often be prevented when and if environmental triggers (e.g., physical inactivity, overconsumption of commercially processed foods, unhealthy body weight, poor sleep-breathing hygiene, etc.) can be identified and removed when/if feasible to do so;
2) If disease signs and symptoms are detected early, ODC can often be successfully reversed and/or controlled (treated);
3) If not prevented, reversed and/or appropriately treated, systemic and/or ODC can seriously threaten health, well-being (quality of life) and survival (longevity/quantity of life).

Plaque-mediated oral diseases

Dental caries, periodontal disease and skeletal-dental malocclusion are three highly prevalent oral health dilemmas known to be associated with the phenomena of early agricultural intensification about 13,000 years ago, and later cultural industrialisation, also referred to as modernisation or so-called nutrition transition in which people switch from a traditional subsistence diet to an industrial age diet of refined sugars and processed foods [Gibbons, 2012; Paglia, 2016]. Cavities and periodontal disease are largely plaque-mediated problems involving a diet-infectious interaction between frequently consumed fermentable (i.e., fiberless)-carbohydrates and acidogenic/aciduric oral flora (e.g., Streptococcus mutans and others) that are capable of producing extracellular polysaccharides that can irreversibly adhere to the enamel pellicle as initial plaque biofilm colonisers and encourage demineralisation and enamel cavitation. By the late 1930s Weston A. Price [2010] was able to document the dental damage and subsequent malocclusion due to a carbohydrate-heavy diet (Westernised diet), compared to the near absence of cavities and malocclusion in those population who were consuming no industrialised foods. Price was able to document that as more industrialised food, which is less chewable and has a high content of refined sugar, was introduced to non-Western populations, changes across generations were visible, shifting from dental malocclusion to skeletal-dental malocclusions. Unfortunately, this tendency has been visibly accelerating worldwide.

Skeletal-dental malocclusion

The components of the mammalian cranio-facial complex (e.g., the tissues associated with the head, face, teeth and jaws) that are dedicated to biological food processing such as chewing, grinding, or tearing, are also intimately connected to the hard and soft tissues of the upper respiratory complex through the nose, the paranasal sinus complex, the pharyngeal corridors, etc. Collectively these two survival apparatuses comprise the Cranio-Facial-Respiratory Complex or CFRC (Fig. 1). The mammalian CFRC comprises several different biological tissues that collectively function under coordination from the central nervous and cardiorespiratory systems primarily to acquire and process ambient air, food, water and also perform communication skills necessary for speech and facial expression, along with auditory, olfactory, visual and tactile acuity.

As pre-modern humans evolved away from their common ancestor with modern chimpanzees some 5–6 million years ago, the CFRC was indispensable for their survival and reproductive fitness. The genomic sequence (genetic material/suites of genes) required for producing the modern human CFRC phenotype is therefore not likely to have changed much over the past several millions of years, and almost certainly has remained unchanged over the past few hundreds of years when malocclusion first became markedly prevalent within industrialised cultures.

Human skeleto-dental malocclusion (SDM) is a condition that was nearly non-existent only a few hundred years ago. Larsen [1995] reports, "…a shift to agriculture or more intensified agriculture was accompanied by an increase in dental crowding and malocclusion."; Gilbert [2001] states, "… jaw anomalies (malocclusions wherein the teeth cannot fit properly in the jaw) are relatively new to European populations. Well-preserved skeletons from the 15th and 16th centuries show almost no malocclusion in the population…"; and Lieberman [2011] reports "…there is much circumstantial evidence [to suggest] that jaws and faces do not grow to the same size that they used to…". The aetiology of SDM is best understood when in accordance with Nesse and Williams' [1991] Mismatch hypothesis for explaining modern human disease vulnerability. Amongst anthropologists (and many other anthropologically informed dental and medical health professionals), mismatch between an anciently-derived CFRC and an (overly processed) food supply, is one of the leading explanations for why worldwide prevalences of malocclusion have only recently spiked in Western-exposed cultures (Fig. 2).

Charles Darwin was amongst the first scientists in the mid-19th century to describe the theoretical process of one species gradually changing into another, as transmutation. Darwin

FIG. 2 A typical upper dental arch from the 15th century from North-East Italy (teeth fell off post-mortem) compared to modern dental arches reflecting the epigenetic changes likely due to different foods consumed.

eventually came to describe this transmutation of species process as Evolution by Natural Selection (NS). According to Darwin and others, the transmutation of one species into a different one can only proceed if certain newly acquired traits can somehow promote a survival and reproductive advantage to the individual organism. As the NS process requires long-term exposures to ever-changing and challenging environmental conditions over vast amounts of geologic time, phenotypic trait alterations can never be seen in real time and is only observable after complete incorporation into a species' genome.

Epigenetic modification, on the other hand, is the process by which an environmental stimulus can affect, albeit without causing a disruption of DNA nucleotide sequences (i.e., mutation), a person's genome sufficiently to bring about a physical or behavioral trait change, but over a relatively short span of time. For example, if a child inherits a subset glycemic-control genes that malfunction when exposed to an unhealthy lifestyle environment (physical inactivity, overconsumption of highly processed foods and poor sleep hygiene, etc.), insulin resistance and a possible diagnosis of type 2 diabetes might be an expressed disease phenotype. Similarly, the multiple chromosomes and specific genes that are responsible for production of the human CFRC, can also be influenced by environmental challenges. Specifically, anthropologists have long recognised that lifelong exposure to modern feeding regimens of readily available and highly processed foods, can impact expression of various phenotypic traits (e.g., cholesterol levels, shape of jaws, insulin response to sugar, etc.) quite differently than does lifelong exposure to more traditional ancestral feeding regimens that are typical of hunter-gatherer/foraging in non-Western-exposed cultures (Nesse, 1994) (Fig. 3).

Orofacial myofunctional disorders

As most all malocclusion phenotypes observed in non-syndromic children nowadays are largely the result of orofacial myofunctional disorders (OMDs) [AAO, 2013], they are accordingly preventable when/if so-called minor (incipient, mild) malocclusion traits (MMTs) such as slight incisor crowding and/or skeletal retrognathia, etc.) appear in early childhood (i.e., under 71 months of age. In terms of being reliably predictive for subsequent dentofacial-related esthetic problems in later life, MMTs are often described as being subtle or non-progressive and thus non problematic, or maybe only minimally problematic. As a result, when MMTs initially become apparent within the primary or early mixed dentition, they are not usually diagnosed and appropriately treated until the problem will have persisted and worsened becoming major malocclusions during later childhood or adolescence. Accordingly, within the American Association of Orthodontist's most recently published brochure entitled Your Child's First Orthodontic Check-up—no later than age 7 [2013], they unabashedly reported a disturbing statistic—'While

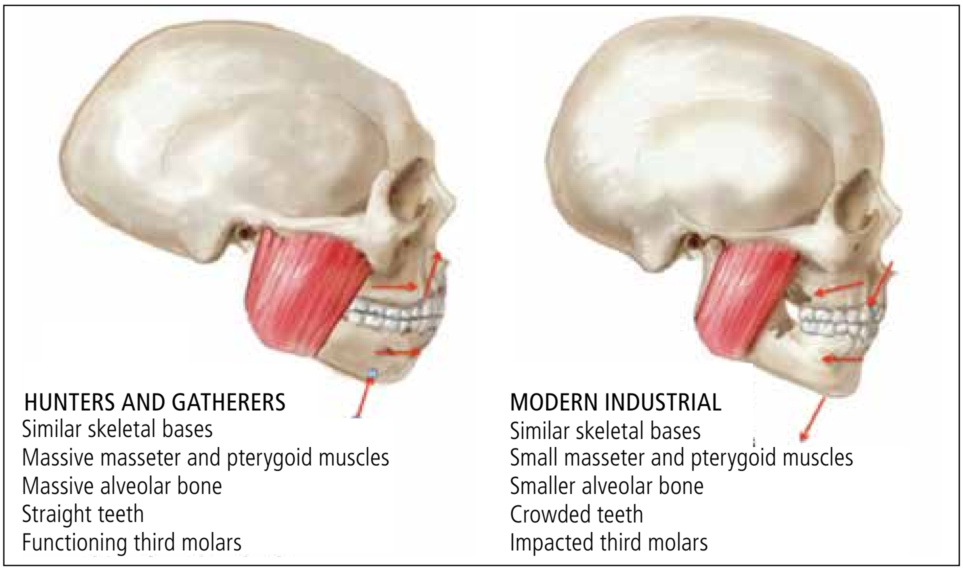

FIG.3 Genetic and epigenetic evolution of the orofacial and cranial complex (Courtesy of OneZero/Medium and Jerry Rose, PhD, Richard Roblee, DDS, University of Arkansas).

orthodontic treatment most often begins between the ages of 9 and 14, some children's orthodontic problems can benefit from earlier treatment.'

The role of the paediatric dentist

Ideally, addressing SDMs requires a multidisciplinary approach that follows a baby from birth through the arch of a life span. Pediatric dentists (and other oro-facial-dental professionals who provide services for children, e.g., general dentists, orthodontists dental hygienists, myofunctional therapists, speech-language pathologists, occupational therapists and more) could have a significant role in preventing, slowing down, reducing or reversing the epigenetic effects of changes impacting humans, therefore patients.

Paediatric dentists and paediatricians need to screen for restricted lingual frena, for which there are several protocols [Saccomanno, 2019; AAO, 2013; Yoon, 2017; Kotlow, 1999]. Although screening for a restricted lingual frenum should be performed at birth, to promote latching [Martinelli, 2016], not all children are assessed at the proper age [Hazelbaker, 1993]. By the time they require orthodontic treatment, many of them have never had their frenum screened.

Depending on the age of the child, dental professionals who provide services to children should consider collaborating with allergists, ENTs and breathing educators to ensure that nasal breathing is restored or maintained, as breathing is the most important life-sustaining function, to which all other functions will adapt and compensate [Dollberg, 2006; Huang, 2015; Abreu, 2008a and 2008b].

Whenever possible, breastfeeding should be encouraged over artificial nursing (i.e., bottle-feeding with commercially produced infant formulas), as humans have pretty much required breastfeeding in order to survive childhood; the Industrial Revolution marks a key point of departure from this vital practice. Breastfeeding assists the anatomo-physiological transition of muscles from sucking to chewing [Bresolin, 1983; Gelb, 2017; Genna, 2017a].

Weaning babies with fresh, fibrous, firmly textured and minimally processed foods, as opposed to pureed, overcooked and fiberless foods, has been a necessity and the norm for the several millennia that had preceded our current industrialised food supply. Currently, infants and toddlers are weaned with so-called "safe" pureed food that minimises or completely bypasses the masticatory/chewing component of the CFRC altogether. Various studies show the impact of a soft diet on the growth and development of the palate, salivary glands and the chewing musculature [Genna, 2017b; Barros de Arruda Telles, 2009; Suzuki, 2007; Okubo, 2006]. Encouraging weaning with chewable food may support a correct growth and development of the CFRC and enhance the sensory-motor functions of eating [Maejima, 2005].

Chewing is the physiological engine for the growth and development of the whole craniofacial complex and dental occlusion [Elewa, 2014; Rapley, 2011; Mavropoulos, 2010; Katsaros, 2006; Kiliardis, 1995; Piancino, 2019; Varrella, 1992; Zink, 2016]. Our ancestors had no other options than to chew food with tough fibrous consistencies. Wild apples, bitter herbs, meat cuts, stale bread or aged cheese were not as easy to chew but the trade off was a reduction or absence of caries, periodontal disease and malocclusions. Currently it behooves dental and other health professionals to promote consumption of fresh and firm foods that require more chewing and educate patients on the benefit of proper chewing, as much as dental hygiene is promoted.

Paediatric dentists, general dentists and orthodontists who provide services for children should become competent in screening their patients for sleep disorders, as they are a nocturnal manifestation of poor breathing. Sleep disorders in children have been documented to affect growth, development, health, behaviour, academic performance and relationships [Guilleminault, 2019, 2017 and 2018; Walter, 2011; Bonuck, 2011]. CFRC's phenotypes that might predict susceptibility to sleep-related breathing disorders (SRBD) co-morbidity, such as a restricted lingual frenum, retrognathic jaws and incompetent lip seal, etc. [Gozal, 1998; Guilleminault, 2016; Quinzi, 2020; Camacho, 2015], are usually readily detectable in pre-school-age children [under 59 months], will nearly always persist into later years [i.e., not self-correct] and often worsen without appropriate intervention [de Felicio, 2016]. The rapid epigenetically-modulated changes that are being wrought upon the human CFRC over recent centuries are directly impacting not only our facial appearances, but also our sleep-airway hygiene, neurological functions and various other related systemic issues. Compared to ancient and more recent non-westernised populations for which sleep had always served as a restorative and regenerative function, unhealthy sleep is reaching global pandemic proportions in many industrialised countries. Rapid palatal expansion (RPE) [Boyd, 2020; Quo, 2017] and orofacial myofunctional therapy (OMT) [Rosa, 2019] can both be considered as either stand-alone intervention strategies for treating SRBD; and since adenotonsillectomy often fails to fully resolve SRBD long term [de Felicio, 2016], RPE and OMT can also serve as an efficacious adjunctive strategy for enhancing surgical outcomes [Saccomanno, 2020].

-Myofunctional therapy can be a viable collaborative opportunity complementary to other efforts by paediatric dentists, general dentists and orthodontist who are challenged with OMDs that might be linked to unfavorable epigenetically-modulated phenotypes. These disease traits might be mitigated through a specific regimen of exercises and strategies aimed at correcting nasal disuse/habitual mouth-breathing, habitual low and forward resting posture of tongue, incompetent lip seal, sub-optimal sucking and swallowing reflexes, and inefficient chewing, along with reducing or eliminating habitual parafunctions. Myofunctional therapy has shown to be useful even in addressing SRBD directly (not as an adjunct modality) [Quinzi, 2020].

Discussion and conclusion

According to D'Onofrio [2019] "The signs and symptoms of OMD can appear in the first weeks of life but can also occur at any point in the lifespan. In addition to providing structural solutions to problems once they occur, dentists and orthodontists must play a proactive role in preventing acquired craniofacial disorders and supporting optimal craniofacial growth. In response to a growing body of scientific and clinical evidence, all medical and dental professionals have a responsibility to screen for daytime and nocturnal breathing disorders, for enlarged and restricted oral tissue in patients of all ages, and for feeding and oral dysfunction early in life. Beautiful babies were meant to grow up to be beautiful adults". To D'Onofrio's informed opinion it could reasonably be added that not only will optimised facial esthetics usually be a desired consequence of correcting OMD and malocclusion co-morbidities, it stands to reason that the optimization of the CFRC's structures and functions as early in a child's life as it might be feasible to do so, will also confer lifelong quality and quantity of life benefits.

If there is one thing that Darwinian Dentistry and Medicine taught us it is that although the human face is gradually changing, as a result of the properties of modern food and how it is consumed, along with the impact of postural and lifestyle changes and the environment on the orofacial functions, health professionals have the knowledge and the tools to positively impact the epigenetic trajectory forming our orofacial structures. The origin of these changes is in our far past but we have some control over their future.

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References

- Abreu RR, Rocha RL, Lamounier JA, & Guerra ÂFM. (2008a) Prevalence of mouth breathing among children. Jornal de pediatria. 2008a; 84(5):467-470. [Portuguese]
- Abreu RR, Rocha RL, Lamounier JA, & Guerra ÂFM. (2008b) Etiology, clinical manifestations and concurrent findings in mouth-breathing children. Jornal de pediatria; 84(6):529-535. [Portuguese]
- American Association of Orthodontists. (2013) Your child's first orthodontic checkup. AAO promotional brochure. accessedFeb,2017,fromhttps://mylifemysmile.org/mylifemysmile/brochures/Your_Childs_First_Checkup.pdf.
- Barros de Arruda Telles F, Ferreira RI, Magalhaes L, & Scavone-Junior H. (2009) Effects of breast- and bottle-feeding duration on the age of pacifier use persistence. Braz Oral Res. 23(4):432-438.
- Bonuck KA, Chervin RD, Cole TJ, Edmond A, Henderson J, Xu L, Freeman K. (2011) Prevalence and persistence of sleep disordered breathing symptoms in young children: a 6-year population-based cohort study. Sleep. Jul 1;34(7):875–884.
- Boyd, KL. (2020) A century of adenotonsillectomy's failure to fully resolve sleep-disordered breathing: mild malocclusions are maybe not so mild? J Clin Sleep Med. 16(8): 1357–1358.
- Bresolin D, Shapiro PA, Shapiro GG, Chapko MK, & Dassel S. (1983) Mouth breathing in allergic children: Its relationship to dentofacial development. Am J Orthod. 83(4):334-340.
- Camacho M, Certal V, Abdullatif J, Zaghi S, Ruoff CM, Capasso R, Kushida CA. (2015) Myofunctional therapy to treat obstructive sleep apnea: a systematic review and meta-analysis. Sleep 38(5):669–675.
- Corruccini RS, Townsend GC, Richard LC, Brown T. (1990) Genetics and environmental determinants of dental occlusal variation in twins of different nationality. Human Biology. 122:353-67.
- Corruccini RS. (1984) An epidemiological transition in dental occlusion in world population. Am J Orthodontics Dentofacial Orthopaedics. 86:419-26.
- de Felício CM, da Silva Dias FV, Folha GA, de Almeida LA, de Souza JF, Anselmo-Lima WT, Trawitzki LV, Valera FC. (2016) Orofacial motor functions in pediatric obstructive sleep apnea and implications for myofunctional therapy. Int J Pediatr Otorhinolaryngol. 90:5-11.
- Dollberg S, Botzer E, Grunis E, & Mimouni FB. (2006) Immediate nipple pain relief after frenotomy in breast-fed infants with ankyloglossia: A randomized, prospective study. J Pediatric Surg. 41(9):1598-1600.
- D'Onofrio L. Oral dysfunction as a cause of malocclusion. Orthod Craniofac Res 2019 May;22 Suppl 1(Suppl 1):43-48.
- Elewa YH, Ichii O, Otsuka S, Hashimoto Y, Kon Y. (2014) Structural changes of goat parotid salivary gland: pre- and post-weaning periods. Anat Histol Embryol. Aug;43(4):265-72.
- Garg RK, Afifi AM, Garland CB, Sanchez R, Mount DL. Pediatric Obstructive Sleep Apnea: Consensus, Controversy, and Craniofacial Considerations. Plast Reconstr Surg 2017 Nov;140(5):987-997.
- Gelb M. Airway Centric TMJ Philosophy. (2017) CDA Journal. 42(8):551-562.
- Genna CW & Sandora L. (2017a) Breastfeeding: Normal sucking and swallowing. In C.W. Genna (Ed.), Supporting sucking skills in breastfeeding infants (3rd ed., pp. 1-48). Woodhaven, NY: Jones and Bartlett Learning.
- Genna CW. (2017b) The influence of anatomic and structural issues on sucking skills. In C.W. Genna (Ed.), Supporting sucking skills in breastfeeding infants (3rd ed., pp. 209-267). Woodhaven, NY: Jones and Bartlett Learning.
- Gibbons A. (2012) An evolutionary theory of dentistry. Science. 336(6084):973–5.
- Gilbert SF. (2001) Ecological developmental biology: developmental biology meets the real world. Dev Biol. 2001;233:1–12.
- Gozal D. (1998) Sleep-disordered breathing and school performance in children. Pediatrics. 102:616– 620.
- Guilleminault C, Huang YS. (2018) From oral facial dysfunction to dysmorphism and the onset of pediatric OSA. Sleep Med Rev. Aug;40:203-214.
- Guilleminault C, Huang YS. Pediatric obstructive sleep apnea: A short review of clinical aspects. (2017) Pediatr Respirol Crit Care Med. 1:39-45.
- Guilleminault C, Huseni S, Lo L. (2016) A frequent phenotype for paediatric sleep apnoea: Short lingual frenulum. ERJ Open Res. Jul 29;2(3):00043-2016.
- Guilleminault C, Sullivan SS, Huang YS. (2019) Sleep-Disordered Breathing, Orofacial Growth, and Prevention of Obstructive Sleep Apnea. Sleep Med Clin. Mar;14(1):13-20.
- Hazelbaker AK. (1993) The assessment tool for lingual frenulum function (ATLFF): use in a lactation consultant private practice [thesis]. Pasadena, CA: Pacific Oaks College.
- Huang YS, Quo S, Berkowski JA, Guilleminault C. (2015) Short Lingual Frenum and Obstructive Sleep Apnea in Children. Int J Pediatr Res. 1:003.
- Katsaros C, Zissis A, Bresin A & Killaridis S. (2006) Functional influence on sutural bone apposition in the growing rat. Am J Orthod Dentofacial Orthop. Mar 129(3):352-7.
- Kiliaridis S. (1995) Masticatory muscles influences on craniofacial growth. Acta Odontol Scand. 53:196–202.
- Kotlow LA. (1999) Ankyloglossia (tongue-tie): a diagnostic and treatment quandary. Quintessence Int. 30:259-62.
- Larsen, CS. (1995) Biological Changes in Human Populations with Agriculture. Ann Rev Anthropol. 24: 185-213.
- Lieberman D. (2011). The evolution of the human head. Belknap Harvard, Cambridge, Massachusetts.
- Maejima M, Abe S, Sakiyama K, Agematsu H, Hashimoto M, Tamatsu Y, Ide Y. (2005) Changes in the properties of mouse tongue muscle fibres before and after weaning. Arch Oral Biol. Dec; 50(12):988-93.
- Martinelli RLC, Marchesan IQ, Lauris JR, Honório HM, Gusmão RJ, Berretin-Felix G. (2016) Validation of the Lingual Frenulum Protocol for infants. Int J Orofacial Myology. 42:5-13.
- Mavropoulos A, Odman A, Ammann P, Killaridis S. (2010) Rehabilitation of masticatory function improves the alveolar bone architecture of the mandible in adult rats. Bone; Sep 47(3): 687-92.
- Nesse R and Williams GC.. (2010) The Dawn of Darwinian Medicine. Quarterly Review of Biology. 66(1):1-22.
- Okubo K, Abe S, Usami A, Agematsu H, Nakamura H, Hashimoto M, Ide Y. (2006) Changes in muscle-fiber properties of the murine digastric muscle before and after weaning. Zoolog Sci. Dec;23(12):1079-84.
- Paglia L. (2016) Is dental caries a multifactorial disease? Likely not! Eur J.Paediatric Dent. Mar 17(1):5.
- Piancino MG, Di Benedetto L, Matacena G, Deregibus A, Marzo G, Quinzi V (2019) Paediatric Orthodontic Part 3. Masticatory function during development Eur J Paediatric Dent. Sep;20(3):247-249.
- Price WA. (2010) Nutrition and Physical Degeneration: A Comparison of Primitive and Modern Diets and Their Effects. Oxford: Benediction Classics.
- Quinzi V, Saccomanno S, Manenti RJ, Giancaspro S, Coceani Paskay L, Marzo G. (2020) Efficacy of Rapid Maxillary Expansion with or without Previous Adenotonsillectomy for Pediatric Obstructive Sleep Apnea Syndrome Based on Polysomnographic Data: A Systematic Review and Meta-Analysis. Appl. Sci. 10, 6485.
- Quo S, Hyunh N, Guilleminault C. (2017) Bimaxillary expansion therapy for pediatric sleep-disordered breathing. Sleep Medicine. 30:45–51.
- Randolph M. Nesse and George C. Williams. (1994) Why We Get Sick: The New Science of Darwinian Medicine. New York: Vintage Books.
- Rapley G. (2011) Baby-led weaning: transitioning to solid foods at the baby's own pace. Community Pract. Jun;84(6):20-3.
- Rosa M, Quinzi V, Marzo G. Paediatric Orthodontics Part 1: Anterior open bite in the mixed dentition. Eur J Paediatr Dent. 2019; 20(1):80-82.
- Saccomanno S, Antonini G, D'Alatri L, D'Angeloantonio M, Fiorita A, Deli R. (2014) Case report of patients treated with an orthodontic and myofunctional protocol. Eur J Paediatric Dent. Jul;15(2suppl):184-6
- Saccomanno S, Di Tullio A, D'Alatri L, Grippaudo C. (2019). Proposal for a myofunctional therapy protocol in case of altered lingual frenulum. A pilot study.C.Eur J Paediatr Dent. Mar;20(1):67-72.
- Saccomanno S, Martini C, D'Alatri L, Farina S, Grippaudo C. (2018) A specific protocol of myo-functional therapy in children with Down syndrome. A pilot study. Eur J Pediatric Dent. Sep; 19(3)243-246.
- Saccomanno S, Quinzi V, Sarhan S, Laganà D, Marzo G. (2020) Perspectives of tele-orthodontics in the COVID-19 emergency and as a future tool in daily practice. Eur J Paediatr Dent. 21(2):157-162.
- Suzuki K, Abe S, Kim HJ, Usami A, Iwanuma O, Okubo H, Ide Y. (2007) Changes in the muscle fibre properties of the mouse temporal muscle after weaning. Anat Histol Embryol. Apr;36(2):103-6.
- Varrela J. (1992) Dimensional variation of craniofacial structures in relation to changing masticatory- functional demands. Eur J Orthod. 14:31–36.
- Walter LM, Nixon GM, Davey MJ, O'Driscoll DM, Trinder J, Horne RS. Sleep disturbance in pre-school children with obstructive sleep apnoea syndrome. (2011) Sleep Med. Oct;12(9):880-6.
- Yoon A, Zaghi S, Weitzman R, Ha S, Law CS, Guilleminault C, Liu SY. (2017) Toward a functional definition of ankyloglossia: validating current grading scales for lingual frenulum length and tongue mobility in 1052 subjects. Sleep Breath. Sep;21(3):767-775.
- Zink KD and Lieberman DE. (2016) Impact of meat and Lower Palaeolithic food processing techniques on chewing in humans. Nature. Mar 24;531(7595):500-3.