Human Dento-Facial Evolution

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1. Human Facial Expression, Language and More Human Abilities

The human smile is a unique facial expression, the origin of which is an open inquiry among species and in human evolution.

The smile is expressed on the face by the combined relaxation/contraction of the different muscles involved (e.g., zygomaticus major and minor, orbicularis oculi, etc.), depending on the type of emotion that the person is expressing, and also differs from person to person as the smile patterns of each person are completely different.. The functions of the smile are signaling and emotion expression, crucial for human language [1]. The nature of the human smile is versatile, having been associated with multiple social tasks including love, sympathy, laughter and war [2]. Smile signaling/function may differ in other species, since it is not unique to humans. For example, in some non-human primates, the smile may be a sign of submission, threat and warning [1]. From a medical perspective, the smile has a direct impact on cosmetic surgery and dentistry. Alterations, developmental and/or acquired, in the smile–teeth–gingiva relationship and as part of the facial framework could modify patient esthetics, affecting clinical outcomes and ultimately social interactions [3]. Current medical/dental standards are aware of the significance of the smile as part of a successful treatment outcome.

Language enabled humans to develop, speak and communicate as a species. Modern human language is composed of gestures and speech. Gestural language may have emerged to enable cultural transmissions of stone tool-making skills in early hominins. While speech may have coevolved as a result of more complex hominins interactions (e.g., social, trade) in ancestors of *Homo sapiens neanderthalensis* and *Homo sapiens* during the Middle Pleistocene [4]. Archeological and genetic evidence show that *Homo sapiens neanderthalensis* an extinct species of archaic humans, possessed some form of language unlike *Home erectus*. A language requires muscle flexibility that was, in part, allowed by muscle relaxation during cranial growth. In contrast to powerful masticatory muscles evidenced in most primates, masticatory muscles are considerably weaker and smaller in both modern and fossil members of *Homo*. Human soft diet and ability to speak do not require strong musculoskeletal structure, nor powerful teeth.

Anthropology recognizes the importance of facial expression and language for human relationships, society and culture. Individual facial recognition requires phenotypic diversity and variation. The number of muscles in the face, larynx and forearm in modern humans is greater when compared to other mammals [5]. The findings are in accordance with the muscle complexity that would be required for language (vocal communication) and to smile (facial expression). The human chin has no functional importance, but is a unique feature used to define *Homo sapiens* [6]. Absent in archaic humans, the development of the human chin that emerged at a time of mid-facial reduction and mandibular shortening contributes significantly to individual facial recognition [7].

Therefore, human cognitive ability can be explained, in part, as the response to the increase in complexity of hominins social interactions. Nevertheless, complex social interactions are not only reflected by human encephalization [8]. Successful social interactions are highly influence by gestural expression allowed by the cranio-facial musculature evolution [5]. Albeit genetic and epigenetic events have enhanced human facial expression, individual recognition and linguistic capabilities over the last 500,000 years, dento-facial complications have increased.

2. Oral Diseases and Dento-Facial Complications

Human evolution is replete with achievements such as the invention of tools, writing, scientific method, mastering of fire/cooking, agriculture and others that all together have influenced human culture. Modern human lifestyle was drastically changed about 12,000 ya, when humans transitioned from a nomadic to a sedentary life. Such a transition has not only impacted human's health, but also the Earth and other species around us [7]. The major leap forward allowed by agriculture has been associated with the increase of dental caries and periodontal diseases, the current two main causes of human tooth loss in modern society.

Association of corn-based agriculture with an increment of caries lesions has been reported [9][10][11][12][13]. Products rich in carbohydrates (sucrose and starches) of domesticated plants with agriculture, combined with food preparation sophistication, have contributed to dental caries. Furthermore, tooth microwear produced by the diverse consistency of aliments create areas for bacteria and micro food particles accumulation [14]. Contrary to the coarse alimentation of prehistoric humans, modern human soft diet, bacteria and microwear may have promoted caries initiation and progression.

The decline in modern human's oral health was also affected by periodontal disease occurrence. Beyond oral health, periodontal disease has impacted humans' social interactions, impacting self-esteem in affected patients. Patterns of dimension reduction of the face, jaws and teeth have been observed in archeological evidence from Neolithic humans [9][11]. This correlates with the increase of periodontal disease incidence [14][15]. The cranio-facial evolution has contributed to dento-facial changes, including an increase in the incidence of impacted teeth and overcrowding in modern humans. Overcrowding creates areas for plaque accumulation and calculus formation, increasing the risk of periodontal disease [16][17]. These human features are associated with periodontal disease progression and prevalence, which contributes to elevated levels of morbidity in the species [12][13][16][17].

Human evolution favored cranial growth by reducing the dimensions of the maxillary and mandibular bones that left limited space for tooth eruption. As a result, the incidence of malocclusion, impaction and overcrowding increased [16][17][18]. Teeth and maxillary/mandibular bones did not reduce dimensions proportionally, mainly due to the differences in origin and development [18][19][20]. General patterns of dental morphological evolution include the loss of the diastema, present in archaic humans. The prevalence and pattern of impacted teeth seem to be similar among different populations [21][22][23]. Despite a change in diet to a less hard/abrasive alimentation, the eventual absence of third molar formation has not been associated with an evolutionary anatomical adaptation [24][25]. The distinctive differences in origin and development of the teeth, maxillary/mandibular bones, cranio-facial bones and musculature have contributed to dento-facial complications such as an increase in the incidence of malocclusion, impaction, overcrowding teeth and obstructive sleep apnea.

Another negative side effect has been the pharyngeal collapse, posterior displacement of the tongue into the pharynx and shortening of the mandible that together have contributed to obstructive sleep apnea [26]. The oropharyngeal evolution is connected to bipedal posture and brain volume increase. Bipedal specializations are evidenced in *Australopithecus* fossils from 4.2–3.9 million years ago [27]. Bipedalism evolved well before the large human brain and required a smaller oral cavity for the arrangement of the center of gravity of human cranium. The upper airway evolution along with the facial shortening facilitated the phonetic ability and the invention of human language.

In addition, cranio-facial growth is influenced by masticatory forces, which in part is altered by diet [16]. Thus, cranio-facial structures adapt to individual species' needs. In particular to humans, the fire/cooking mastery and agriculture-related dietary modifications over time affected the mastication, decreasing humans' need for strong musculature and teeth required for a hard abrasive alimentation. Stedman et al. provided evidence that the gene encoding the predominant myosin heavy chain (MYH) was inactivated by a mutation. The mutation appeared 2.4 million years ago as estimated by molecular clock, predating the appearance of the modern human body size [1]. The chewing activity of humans is less efficient when compared to other mammals and archaic hominins. Loss of this protein isoform may have been associated with a marked size reductions in entire masticatory muscle fibers that also favored cranial capacity increase by muscle relaxation. Overall, the modern human experienced morphological changes driven by evolutionary processes that negatively impacted health. However, the morphological adaptations presented an opportunity that ultimately allowed humans to improve cognitive ability, smile, speech, and individual facial recognition.

3. Perspectives

Dentistry has experienced periods of major excitement followed by severe disappointments. The limitations in the treatment modalities can be explained, in part, due to the complexity of the life forms that resulted from evolution and dynamics between bacteria, viruses, immune responses, genetic and epigenetics factors that have caused dento-facial complications.

Caries and periodontal disease remain the main pathologies affecting oral health causing tooth loss [28][29]. The standard of care for caries and periodontal disease remains primitive modalities consisting of the removal of the infected tissues. Treatment of caries, a disease mainly caused by Gram-positive bacteria, consists of mechanical removal of infected dentin and application of fillers (amalgam, composite, ionomer, gold or ceramic materials). Periodontal disease is caused by protective and destructive immune responses responding to bacterial and viral pathogens. Currently, the treatment for periodontal disease constitutes mechanical therapy (non-surgical and surgical), antiseptics and systemic antibiotics [29].

Sophisticated treatments like regeneration have yielded long-term disappointing results. Regeneration remains an important therapeutic goal in dentistry. However, the cellular inductive processes that regulate the differentiation and maturation of the teeth and periodontal tissues are not well understood yet. Considering the complexity of evolution and organogenesis in tooth development, it may be difficult to perceive that the mere placement of devices such as membranes, grafts (autologous, allografts, xenografts or synthetics) and growth factors would be sufficient to induce formation of the highly sophisticated periodontal tissues that resulted from billions of years of evolution. The case of guided tissue regeneration for periodontal patients is an example in dentistry of a period of major excitement followed rapidly by severe disappointment. Presently, “regenerative” procedures continue to be performed in hopes of an occasional dramatic result limited by current knowledge and technology [30].

Implant therapy for tooth replacement along with dental implant related surgeries that involve soft tissue and bone augmentation have increased significantly. Nevertheless, it has been demonstrated that peri-implant tissues are more susceptible to bacterial/viral challenges when compared to periodontal tissues (periodontium) [31]. Peri-implantitis is characterized by inflammation of the peri-implant tissues and loss of supporting bone. The human-made disease of peri-implantitis is considered to be growing problem in dentistry [32]. Perhaps, the differences in susceptibility lie in the differences in origins of the surrounding tissues. The periodontium forms from Hertwig’s epithelial root sheath, while the junctional epithelium from the reduced enamel epithelium [33][34]. The peri-implant tissues form as a response to the phenomena of osseointegration during the wound healing process, divided into bone and soft tissue compartments [31]. Developmentally, the formation of the periodontium when compared to peri-implant tissues is superiorly organized and sophisticated. Moreover, implant dental therapy limitations to restore the original architecture found in the natural pristine permanent dentition have been evidenced. However, dental implants have provided acceptable treatment outcomes that clinicians and patients have benefited from [35]. In the quest to provide functional and esthetics results, clinicians have suggested a variety of techniques, grafts and implant design modifications with occasionally disastrous results [36]. Currently, no treatment modality is able to restore the tissues that nature has developed during millions of years of evolution.

Treatment for impacted teeth consists usually of a combination of orthodontic and surgical treatment. Nowzari and Rodriguez, from an evolutionary perspective, reported on how tooth impaction in modern humans has compromised orthodontic treatments and recommended the use of a closed flap surgical technique for the management of impacted teeth [18]. Currently, the treatment of choice for obstructive sleeping apnea consists of devices for a continuous positive airway pressure (CPAP). Dentists and specialists seeking to prevent and/or provide reliable long-term results for treatment of these maladies are constantly challenged by inconsistent results.

Authors have highlighted the importance of the evolutionary events that modern humans have experienced to understand in more depth current clinical challenges.

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