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Evolution of oral maxillofacial complex in Homo sapiens (Modern man) - an overview*

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Abstract

The orofacial complex of Homo sapiens (modern man) have evolved, from the common ancestor of chimpanzee and men to their current form. Various elements like food eaten and the processing of foodstuff by fire and usage of tools have exaggerated this evolution. Correspondingly, the evolution of the oral maxillofacial complex is associated to other anatomical structures such as brain size and bipedal posture and has led to notable changes like the development of speech and language. In this review, the evolution of human jaws and teeth and its impact on the general progression of human evolution is discussed.

Keywords: evolution; human oral maxillofacial complex; jaws

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Introduction

Human evolution is the evolutionary progression inside the history of primates that led to the dawn of Homo sapiens (modern man) as a distinct species of the hominid family, which includes the great apes. This process involved a steady progress of traits like human bipedalism, larger brain size, language, extended ontogeny (gestation and infancy) and reduced sexual dimorphism (1). It also incorporates interbreeding with other hominins, suggestive of human evolution being a web process, and not a linear one.

The study of human evolution includes scientific specialities, such as primatology, palaeontology, https://en.wikipedia.org/wiki/Primatologyarchaeology, anthropology, neurobiology, ethology, evolutionary psychology, embryology, linguistics, genetics as well as dentistry (1).

This field, although not considered within the scope of dentistry, the overall oral and maxillofacial structure provides important evidence for human evolution.

Teeth are composed of the most durable tissues, that is, enamel and dentine, ensuring their post-mortem survival long after all other tissues have decayed, or fossilised. Teeth allow direct comparison between extant and fossilised specimens formed millions of years apart. Teeth, depict their genetically inherited patterns, and therefore prove their evolutionary history, more accurately than any other organs, after post-mortem study. Apart from the genetic evidence to be taken from dental morphology, significant information has been obtained about the nature of the diet, and indirectly, the cultural and evolutionary status.

Human masticatory system, comprising of maxilla, mandible, teeth, temporomandibular joint, and the muscles of mastication, is functionally involved in chewing and speech. Just like all other anatomical features of human species, the masticatory system has also evolved during the evolution of homo sapiens.

Dental and orofacial features of the extinct hominin taxa

The jaws and teeth of a human being is much smaller compared to great apes' (2). Fossil research have also backed up the evidence of a reduction in the size of the masticatory system in the hominins, acknowledged to be the ancestors of Homo Sapiens. Palaeontologists have stated that this was due to the changes in the eating patterns of the evolving species (3 -5).

There are morphological differences that distinct the modern humans from living apes, based on characteristics of the dentition, skull, brain, trunk, etc. For example, canine of the apes is sexually dimorphic when compared to the humans (6). Human jaws are not only smaller, but more gracile and less projective than those of giant sized of living apes (7). These structures, that differentiate the modern humans from living apes, could also be found between modern humans and early hominins, even though together, with similarities between the taxa.

Lucas et al. (8) accepted that the dental characteristics of the last common ancestor of chimpanzees/ bonobos and hominins had big incisors and were procumbent when first erupted. They had sexually dimorphic canines, with males having more projected canines compared to the females. Second molar was the largest of the molars, just like in all of the great apes while premolars had smaller crowns.

However, the incisor teeth were comparatively small and more vertical in the archaic megadont hominins and the genus Homo (9). This decrease in the incisal size was shared with the increase in size of the premolars and molars (10).

In the new age humans, the first molars are the largest amongst the molars, however, the overall tooth size has decreased (11). In the earliest hominins and archaic hominins, second molars were usually the largest of the molar teeth and the third molars and second molar size were similar (12).

Characteristic maxillofacial anatomical structures of Homo sapiens

The protuberant chin is one of the evolutionary structures which distinct Homo sapiens from our ancestors. A prominent chin was not present in archaic humans and Neanderthals (2, 13), Figure 1. Numerous papers have been published on the evolutionary changes in chin, specifically on its role and biomechanical foundation. Some researchers stated that the chin provided resistance to meandering forces on the lower jaw (14), few others, including Liberman (15) mentioned that the chin had no functional significance. Masticatory structure related biomechanical forces were stated as an essential factor in the development of the human chin.

Nevertheless, conflicting opinions claim that the formation of the human chin occurred at a time of

diminished dental use and mandibular shortening (16). Some researchers have insisted that the diminishing size of the dental arch made the chin protrude. Ichim et al. asserted that initiation of speech led to the development of the chin, as a result of recurring contractions of the tongue and the perioral musculature, based on the finding that the projection of chin overlaps with the origin of speech 50,000 years ago (17).

The origination of pottery (the pottery Neolithic period, 7,600-7,000 uncalibrated radiocarbon years before present) and thus the changes in food production, were assumed to relax the selective forces on the masticatory system. This led to the onset of probable mutation effect resulting in a consequent reduction in tooth size (21).

An option for reduction in intake and metabolic nutrients directed to a comparable reduction in body size was stimulated by these novel adjustive forces. This overall reduction in body size resulted in a decrease in tooth size (22).

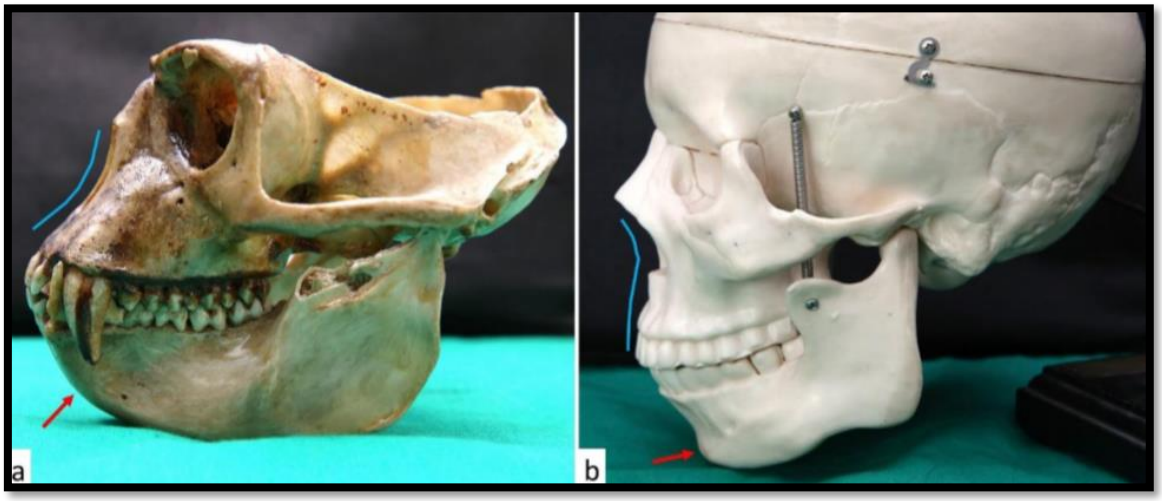

Figure 1 Evolution of Human face with simultaneous changes in chin prominence and jaw size. a) Earlier primates, b) Human skull. [Source: Museum specimens, Government Dental College and Hospital, Mumbai].

Diet and dental evolution

Teaford and Ungar have publicized that 2.3 to 4.4 million years ago, there have been changes in the dietetic habits and patterns of the first hominins (australopithecines), which have given them the opportunity to sustain in diverse territories enabling them to consume a great variety of food (18).

Jolly CJ specified that these australopithecines had smaller incisors related to the molars and stated that this might have been due to telluric seed consumption (19). Australopithecines also had big and flat molars, suitable for hard brittle foodstuffs like some hard fruits, nuts and buds (20).

Teaford and Ungar (18) claim that there is a possibility of the australopithecines using tools for eating meat. The theory says that, with the practice of using tools for cutting and grinding, there was a drastically reduced requirement for carnivore adaptive features, like large canines, strong jaw and powerful masticatory muscles.

Cooking is an additional feature that caused decreasing the requirement for carnivore adaptations. The first evidence of cooking dates back to 2,00,000- 3,00,000 years ago (23, 24). Cooked and softened food, does not necessitate a robust musculoskeletal build and sharp teeth.

Various authors have reported a decrease in the dental dimensions that started to appear with the use of controlled fire for cooking (23, 25). It is also stated that the control of fire and the use of language are powerfully related, for educating the next generation how to use fire needs the use of language (26).

Speech and The Upper Airway

Evolution of human maxillofacial system is not only associated to eating and chewing food techniques, but also to brain size, bipedalism and speech.

It has also been stated by Milton that, speech empowered humans to orchestrate their

movements for providing food and rise the hunting capability of our species (5). Hiimae specified that human oropharyngeal system juxtaposed from other mammals for having communication as a foremost function (27). He has stated that use of language is as a result of synchronization in the functions of oropharynx, tongue, teeth and lips.

The importance of speech on evolution of maxillomandibular and oropharyngeal structures was also specified by Lieberman who has reported that the supralaryngeal airway of humans was disparate from other mammals, with food following the same path with the air, which can multiply the danger of airway obstruction while consuming food by the swallowing of edibles into the larynx (28). Further, he elaborated that the chewing action of humans was less effective when compared to the other mammals and archaic hominids because of the decreased size of the palate and the mandible. According to Lieberman, this may be responsible for the crowding of the teeth and impactions. But these disadvantages are well-adjusted by the augmented phonetic capability of human oral system.

Cziko published that the evolution of the maxillomandibular system was thoroughly associated to the development of brain, by emphasizing that speech offers communication and harmonization between the personnel's and also plays an important role in thinking (29).

It has been theorized earlier that, a bigger cranial vault for a bigger brain is well-kept by the reduction in the size of the oral cavity. Also, the bipedal posture needed smaller oral cavity for the pre-arrangement of the centre of gravity of human skull (2).

Even if many primates, including some hominins like the australopithecines, have strong muscles of mastication, members of Homo tend to have smaller masticatory muscles (2). It was found that, the orofacial complex of the hominin clade moved in the direction of elegance along with greater encephalization in early Homo (30). Stedman and co-workers insisted that, a gene encoding the main myosin heavy chain (MYH) expressed in the masticatory muscles was deactivated by a mutation at the time of deviation within humans and chimpanzee (31). They have dated this mutation back to 2.4 Ma predating the emergence of modern human body size and migration of Homo from Africa (32). The loss of this protein isoform gave rise to decrease in size of muscle fibres and entire masticatory muscles. It is believed that the skull dimension rises as an outcome of this waning of the muscles, relieving the compression on the sutures leading to greater encephalization (32).

Conclusion

The evolution of human orofacial complex is greatly linked to food habits, the usage of tools and fire, and also to the application of speech, playing a very crucial part in the evolution of mankind.

Declaration of interest

None.

Authors' contributions

The authors contributed in the following way:

Dr. Resham AV: Data acquisition and interpretation, literature search and manuscript preparation as well as editing.

Dr. Vivek Pakhmode: Data acquisition, definition of intellectual content, literature search, and manuscript preparation.

Glossary

- Taxa: taxa (taxon is the singular form of taxa) refers to the various classifications of living organisms.
- Hominid: a primate of a family (Hominidae) which includes humans and their fossil ancestors and also (in recent schemes) at least some of the great apes.
- Hominin: a primate of a taxonomic tribe (Hominins), which comprises those species regarded as human, directly ancestral to humans, or very closely related to humans.
- Extant: still in existence; surviving.
- Extinct: (of a species, family, or other group of animals or plants) having no living members; no longer in existence.
- Archaic: very old
- Neanderthals: an extinct species of human that was widely distributed in ice-age Europe between 120,000 and 35,000 years ago, with a receding forehead and prominent brow ridges.
- Australopithecus: a fossil bipedal primate with both ape-like and human characteristics, found in Pliocene and Lower Pleistocene deposits (4 million to 1 million years old) in Africa.

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