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A Review of The Mandible

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INTRODUCTION

There are two individuals who are historically known as the founders for the study of osteology and they are Andreas Vesalius and Galen (Luft, 2001). In 1543 Andreas Vesalius discredited many of Galen's original understandings of the human anatomy system when he published his book *De humani corporis fabrica*, and in this book he becomes one of the first to describe in great detail the human mandible and its components (Luft, 2001). Originally, the term maxillae was used to describe both upper and lower jaws until later when the term mandible became the primary word to describe the lower jaw (Wain, 1958). The word mandible stems from the Latin word Mandibulum- which is a derivative from the Latin verb mandere, meaning to chew (Skinner, 1961).

Before beginning a discussion about the mandible bone, it is important to recognize that anthropology and all of its sub-disciplines are rooted in imperialist ideologies which aim to assimilate and suppress minority individuals' rights to sovereignty. (Baloy, 2016; Thomas, 2000; Wagner, 2010). White settler colonialism intended to eradicate indigenous individuals from their ancestral homeland by discrediting their own humanity; one way this act was carried out was through the (pseudo)science of phrenology (Baloy, 2016; Thomas, 2000; Wagner, 2010). The now illegal practice of collecting Indigenous skulls (due to the passing of NAGPRA) for "scientific purposes" was widely accepted during the nineteenth century because studying "the other" became a way to justify colonial dominance over individuals (Thomas, 2000; Wagner, 2010). The ghosts of colonialism still linger within every institutional classroom that fails to recognize the role that science and academia played/s in the demoralization and mistreatment towards people of color (Baloy, 2016; Wagner, 2010).

THE HUMAN MANDIBLE

The human mandible is one of 28 bones in the human skull (White et al., 2012). The mandible, or lower jaw, articulates to the rest of the skull with the help of the mandibular condyles which connect with the temporal bone by the temporomandibular joints (White et al., 2012). The mandible plays a major role in mastication, because many muscles used for chewing are attached to it, and it holds in place 16 teeth (14 with the third molar extracted) (White et al., 2012). The two most basic parts that assist with mastication are the corpus of the mandible and the ramus (White et al., 2012). It is understood in osteology that the mandible has 29 recognized features (White et al., 2012). For the purpose of this paper not every feature will be mentioned. The human mandible is split into right and lefts halves before ossification happens at around the age of one; the result of an ossified mandible is the mandibular symphysis (White et al., 2012). The corpus is somewhat easy to identify in the field because it lasts the longest and is distinguishable by having the thickest amount of bone as well as pockets that secure the teeth in place (White et al., 2012). Within the corpus, there are bony sockets which hold the root of the tooth in place called the alveoli (White et al., 2012). The perpendicular part of the lower jawbone is called the ramus (White et al., 2012).

In order for the nerves and mental vessels to transmit information they must pass through the mental foramen, located towards the anterior of the lateral corpus (White et al., 2012). Underneath the cheek lies the buccinator muscle which helps with mastication; this muscle attaches to the mandible at the extramolar sulcus (White et al., 2012). In order to be able to raise the hyoid bone and the tongue, the mylohyoid muscle needs to attach to the mylohyoid line which is found on the medial edge of the mandibular corpus; the mylohyoid groove is where the mylohyoid nerves and vessels are anchored (White et al., 2012). The purpose of the mental spines is to support tongue muscles and is located on the medial side of the mandibular corpus when viewed from an inferior angle (White, et al., 2012). One feature that is found to be unique to only *H. sapiens* is the presence of a mental protuberance; mental protuberances vary from individual to individual and may be a result of mandibular symphysis (Schwartz, 1998; White et al., 2012). The mandibular condyles (which articulate with the temporal bones) aid the jawbone to open and close, and the condylar neck is what stabilizes this movement (White et al., 2012). The coronoid process also helps to open and close the jawbones (White et al., 2012). When looking at living human beings, the gonial angle helps create an individual's lower face shape which is helpful for forensic facial reconstruction (White et al., 2012). Lastly, there is the mandibular foramen which can be seen on the medial edge of the ramus from an inferior view (White et al., 2012).

EVOLUTION

The evolution of the mandible began in the ocean; trilobites that date back to 530 million years ago have been found with bite marks on their sides (Gidez, 2008). At Ohio State University osteologists matched those same bitemarks on the trilobites to the extinct species *Anamalocaris*, which may have had one of the earliest forms of a jaw (Gidez, 2008). Then, 430 million years ago when primitive fish (Placoderms) started to evolve, fish that carried a trait that resulted in having bony arches that were set forward were better equipped for grasping onto food with a stronger grip (Gidez, 2008). For *Dunkleosteus terrelli,* an ancestral shark species who lived in the ocean around 358-382 million years ago, it was advantageous to have a scissor blade jaw system with no teeth but sharp enamel along the rim of the jaw bones; they were able to extend their mouths to an angle of 45 degrees and snap down with great force onto prey (Gidez, 2008; Anderson et al., 2009). Compared to the jaw system of modern sharks that have a five-part protruding bite that extends and retracts within 50-70 milliseconds- this allows sharks to retain speed while hunting which gives them an edge as a predator (Gidez, 2008).

The jawbone is considered to have played an instrumental role in the diffusion and variation of gnathostomes or vertebrates with jaws (Compagnucci et al., 2013). Today, the most powerful set of jaws belongs to order Crocodilia (Gidez, 2008). When tetrapods started to evolve and make the transition to land around 370-320 million years ago, they retained the trait of having jaw bones (Janvier, 2002; Leblanc et al., 2013). One study, which focused upon the teeth of diadectids, an extant member of Chordata, Tetrapoda, found the presence of cementum around the roots, a periodontal ligament and an alveolar bone. These same features can also be seen in modern mammals (Leblanc, et al., 2013).

Throughout time, the mandible has continued evolve morphological variation across mammals (Grotepass et al., 1997). When some reptiles began the evolutionary transition into mammals, the hyaline-cartilage joint on the mandible was lost and replaced with the temporo-mandibular joint (TMJ), attaching the mandible to the temporal bone (Grotepass, et al., 1997). The adoption of this joint in *H. sapiens* may have played a role in the introduction to a high-fiber diet (Grotepass, et al., 1997). Variation in the location of the TMJ in mammals may contribute to the wide array of mandibular morphological differences and dietary variation between species (Grotepass, et al., 1997).

Mandibular morphology does not vary just between species, but also between individuals within a genus (Grotepass et al., 1997; Spoor et al., 2015). One of the earliest, most complete mandibles in the archaeological record belongs to genus *Homo*, commonly known as the Olduvai

Hominid (OH7) dating to approximately 1.8 million years ago (Spoor, et al., 2015). In comparison to the wide U-shaped dental arcade seen in modern *H. sapiens*, OH7's dental arcade is pinched which creates a V-shape when viewed from a superior angle. This closely resembles more primitive mandibular morphology in early hominins like *Australopithecus afarensis* (Spoor et al., 2015) The adoption of different types of diets may have contributed to the variation seen in lower jaw morphology in *H. sapiens* (Grotepass, et al., 1997; Raia, et al., 2018; Yusuf, et al., 2011).

COMPARING MANDIBULAR MORPHOLOGY

In mammals, there is a wide amount of variation in the morphology of the mandible (Grotepass et al., 1997). When observing *Lynx* mandibles and comparing them to human mandibles there are quite a few differences. The dental formula for a lynx is 3-1-2-1 compared to the 2-1-2-3 dental formula found in humans (Kelson, 1946; Marti et al., 2018). The canine teeth are significantly larger and heavier than those of a human, because they are carnivorous animals and depend on using their canines to tear of raw meat chunks off of prey (Kelson, 1946; Marti et al., 2018). Having six incisors is also more advantageous for the lynx to better tear off meat from prey (Kelson, 1946; Marti, et al., 2018). In total, a lynx will carry 28 permanent teeth throughout life (Marti, et al., 2018). Lynx can also open their jaws much wider than humans due to having more surface area around the mandibular condyles (Kelson, 1946). One similarity that is seen in lynx, as well as humans and other mammals, is the presence of a temporomandibular joint which allows the jaw to move laterally and helps to chew tough foods (Figueirido et al., 2011; Grotepass et al., 1997).

DIVERSITY/INCLUSION/BIOETHICS

The racially charged osteological research of the past continues to have long lasting effects within the discipline (Kakaliouras, 2008). Adopting a holistic approach that emphasizes collaboration and building relationships has resulted in the adoption of repatriation, which is the process of returning any remains or artifacts that are deemed culturally significant by members of a recognized tribe (Kakaliouras, 2008; Thomas, 2000). Before the passing of the Native American Graves Protection and Repatriation Act in 1990, stealing and exploiting remains of non-white individuals was considered to be a widely accepted practice (Thomas, 2000). All sorts of arbitrary analyses were used (like phrenology mentioned earlier) to justify white colonial dominance over the rest of the world (Thomas, 2000). Today, there still is a lack of indigenous representation within the field of anthropology and all of its sub-disciplines, especially osteology (Thomas, 2000).

Within osteology there is a handful of ethical concerns that come alongside when working with human remains (Katzenberg, et al., 2018). It is important to pay close attention to how remains are curated, handled and collected (Katzenberg, et al., 2018). There are many different beliefs that surround the treatment of the dead and it is the job of professionals to consider those beliefs when conducting research so that those same exploitive techniques are no longer practiced (Katzenberg, et al., 2018). Working with human remains can be a difficult task and can lead to the demoralization of individuals if one does not go about conducting research in an ethical manner (Katzenberg, et al., 2018). In the past, there was a wide division between science and cultural belief, but now, in order to properly respect those who have passed, those two aspects must be considered as equally important (Katzenberg, et al., 2018).

FORENSIC APPLICATION

In forensics, the mandible is quite useful because of its close connection with the teeth (Patidar et al., 2010; Singh et al., 2017). Deoxyribonucleic acid (DNA) analysis is one of the main ways to identify human remains, and teeth are proven to be the most successful quantitative source (Patidar et al., 2010; Singh et al., 2017). If teeth are not present on the mandible, the ramus can also be used as a source for DNA analysis which can help identify an individual for forensic investigations (Singh et al., 2017). The morphological variation on a mandible is a good indicator of age (Singh et al., 2017). In cases of natural disasters such as wildfires, having teeth can occasionally allow professionals the ability to identify individuals, because out of all the human bones, they are the most resistant to heat (Patidar et al., 2010). Having access to even one individual tooth may be one of the most helpful things for a forensic investigation (Pretty et al., 2001; Shah et al., 2019). Through postmortem dental profiling, not only can a tooth reveal information about a individual's age, but also blood type, sex, ancestry, and diet (Pretty et al., 2001; Shah et al., 2019).

FUTURE ENDEVORS

Today technology is continuing to revolutionize the way professionals study human remains. Since virtual reality reconstruction is improving in quality, it can be used to help recreate a perpetrator's dental arcade just from bite marks on a victim (Shah, et al., 2019). In the future, postmortem dental profiling will continue to become more accurate and someday may even help forensic professionals with determining every biological and cultural aspect about an individual (Pretty et al., 2001). Within the field of forensics there is a push to ask dentists to label implanted teeth such as dentures, which could aid in the identification process (Pretty et al., 2001). In the case of mass disasters, developing higher quality plans for dental identification teams is something that is going to be improved upon in the future, such as running mock disaster scenarios (Pretty et al., 2001). Lastly, craniomaxillofacial (CMF) injuries are being observed in the context of war to determine the intensity of battle injuries compared to previous wars (Hale et al., 2010). In the Iraq war there is a higher amount of CMF injuries compared to any previous American war (Hale et al., 2010).

CONCLUSION

The mandible is a unique bone that has proven itself to be a beneficial trait from an evolutionary standpoint (Compagnucci et al., 2013; Gidez, 2008). Not only is a jawbone useful for developing a unique diet, but it is useful for survival and communication (Compagnucci et al., 2013). When the first vertebrates started to develop jaw like bones, better predation strategies started to develop; these strategies gave certain predators an evolutionary advantage over their competitors (Anderson et al., 2009; Gidez, 2008). Now, the jawbone has evolved to accommodate to the unique needs of a species (Grotepass et al., 1997; Spoor et al., 2015). Morphology of the mandible varies between species and within a species and is influenced by factors such as diet (Grotepass et al., 1997). In forensics, there is a wide variety of advantages that come with having the mandible bone present in an investigation (Patidar et al., 2010; Pretty et al., 2001; Singh et al., 2017). Using DNA analysis, the mandible or teeth can be used to help recreate the biological aspects of an unidentified individual (Singh et al., 2017). Working with human remains requires dedication and deep respect towards ethical boundaries (Katzenberg et al., 2018). Osteological research continues to improve as technology continues to advance but, it is important to remember that bones are remnants of a lived experience which requires professionals to treat those bones with upmost respect (Katzenberg et al., 2018).

REFRENCES CITED

Anderson, P., & Westneat, M. (2009). A Biomechanical Model of Feeding Kinematics for *Dunkleosteus terrelli* (Arthrodira, Placodermi). Paleobiology, 35(2), 251-269.

Baloy, N. (2016). Spectacles and spectres: Settler colonial spaces in Vancouver. Settler Colonial Studies, 6(3), 209-234.

Compagnucci, C., Debiais-Thibaud, M., Coolen, M., Fish, J., Griffin, J., Bertocchini, F., . . . Depew, M. (2013). Pattern and polarity in the development and evolution of the gnathostome jaw: Both conservation and heterotopy in the branchial arches of the shark, *Scyliorhinus canicula*. Developmental Biology, 377(2), 428-448.

Grande, S. (2015). Red pedagogy native American social and political thought. Lanham: Rowman & Littlefield.

Hale, R., Lew, T., & Wenke, J. (2010). Craniomaxillofacial Battle Injuries: Injury Patterns, Conventional Treatment Limitations and Direction of Future Research. Singapore Dental Journal, 31(1), 1-8.

Figueirido, B., Macleod, N., Krieger, J., De Renzi, M., Pérez-Claros, J., & Palmqvist, P. (2011). Constraint and adaptation in the evolution of carnivoran skull shape. Paleobiology, 37(3), 490-518.

Gidez, C. (Director), Lattanzi, B., & Gidez, C. (Producers). (2008). Jaws [Video file]. A&E Television Networks. Retrieved from Academic Video Online: Premium database.

Grotepass, W., & Thackeray, J. (1997). The temporo-mandibular joint in mammalian evolution, with special reference to "Mrs Ples" and other hominids. South African Journal of Science, 93(4), 181.

Janvier, P. (2002). Gaining ground: The origin and evolution of tetrapods. Nature, 419(6905), 339-340.

Kakaliouras, A. (2008). Leaving few bones unturned: Recent work on repatriation by osteologists. American Anthropologist, 110(1), 44-52.

Katzenberg, M. (2018). BIOARCHAEOLOGICAL ETHICS. In Biological Anthropology of the Human Skeleton (pp. 1-42). Hoboken, NJ, USA: John Wiley & Sons.

Kelson, K. (1946). Notes on the comparative osteology of the bobcat and the house cat. Journal of Mammalogy, 27, 255-64.

Lague, M. R., Collard, N. J., Richmond, B. G., & Wood, B. A. (2008). Hominid mandibular corpus shape variation and its utility for recognizing species diversity within fossil Homo. *Journal of anatomy*, *213*(6), 670–685. doi:10.1111/j.1469-7580.2008.00989.x

Leblanc, A. R. H., & Reisz, R. R. (2013). Periodontal Ligament, Cementum, and Alveolar Bone in the Oldest Herbivorous Tetrapods, and Their Evolutionary Significance. PLoS ONE, 8(9). doi: 10.1371/journal.pone.0074697

Luft, E. V. D. (2001). Andreas Vesalius. In N. Schlager & J. Lauer (Eds.), *Science and Its Times* (Vol. 3, pp. 206-207). Detroit, MI: Gale.

Marti, I., & Ryser-Degiorgis, M.-P. (2018). A tooth wear scoring scheme for age estimation of the Eurasian lynx (*Lynx lynx*) under field conditions, 64(4), 37. doi:10.1007/s10344-018-1198-6

Mounier, A., Marchal, F., & Condemi, S. (2009). Is *Homo heidelbergensis* a distinct species? New insight on the Mauer mandible. Journal of Human Evolution, 56(3), 219-246.

Patidar, K., Parwani, R., & Wanjari, S. (2010). Effects of high temperature on different restorations in forensic identification: Dental samples and mandible. Journal of Forensic Dental Sciences, 2(1), 37-43.

Pretty, I., & Sweet, D. (2001). A look at forensic dentistry--Part 1: The role of teeth in the determination of human identity. British Dental Journal, 190(7), 359-366.

Raia, P., Boggioni, M., Carotenuto, F., Castiglione, S., Febbraro, M. D., Vincenzo, F. D., … Manzi, G. (2018). Unexpectedly rapid evolution of mandibular shape in hominins. *Scientific Reports*, *8*(1). doi: 10.1038/s41598-018-25309-8

Schwartz, J., & Tattersall, I. (2000). The human chin revisited: What is it and who has it? Journal of Human Evolution, 38(3), 367-409.

Shah, P., Velani, P., Lakade, L., & Dukle, S. (2019). Teeth in forensics: A review. Indian Journal of Dental Research, 30(2), 291-299.

Singh, S., Bavle, R., Konda, P., Venugopal, R., Bopaiah, S., & Kumar, S. (2017). Assessment of the most reliable sites in mandibular bone for the best deoxyribonucleic acid yield for expeditive human identification in forensics. Journal of Oral and Maxillofacial Pathology : JOMFP, 21(3), 447-453.

Skinner, H. (1961). The origin of medical terms. Williams & Wilkins.

Spoor, F., Gunz, P., Neubauer, S., Stelzer, S., Scott, N., Kwekason, A., & Dean, M. C. (2015). Reconstructed Homo habilis type OH 7 suggests deep-rooted species diversity in early Homo. *Nature*, *519*(7541), 83–86. doi: 10.1038/nature14224

Thomas, D. (2000). Skull wars : Kennewick Man, archaeology, and the battle for Native American identity (1st ed.). New York, N.Y.: Basic Books.

Wagner, K. (2010). Confessions of a Skull: Phrenology and Colonial Knowledge in Early Nineteenth-Century India. History Workshop Journal, 69(1), 27-51.

Wain, H. (1958). *The story behind the word: Some interesting origins of medical terms*.

White, T. D., Folkens, P. A., & Black, M. T. (2012). *Human osteology*. Burlington: Academic Press.

Yusuf, E., Yalcin, S., & Aybar, B. (2011). On The Evolution of Human Jaws and Teeth: A Review. *Bulletin of the International Association for Paleodontology*. Retrieved from https://doaj.org/article/6ec4e8bb68744a179ae6b49ff996f862