Are third molars becoming vestigial in *Homo sapiens*?

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Abstract

Wisdom teeth in *Homo sapiens* display numerous complications including impaction and infection which can lead to death. Given the mortality that can result from infected wisdom teeth, why do they still occur in most (but not all) modern populations? To answer this question, one must determine the past evolutionary function of wisdom teeth and compare it to the current function of wisdom teeth. In order to explore this question, one must first determine how wisdom teeth provided an essential function in the past; one example is the replacement for worn-down second molars. Investigators compared tooth wear in Neanderthals and two populations of *Homo sapiens* (hunter – gatherer and pastoralists/farmers) in order to determine the function of third molars in each group. Evidence suggests that wisdom teeth are still necessary for mastication in Hunter and Gatherer populations; however, the teeth no longer provide a substantial benefit like they once did. The dental records and complications in pastoralist/farming communities of *Homo sapiens* suggest that wisdom teeth no longer provide an essential role to people living in agricultural societies because of the increase in surgical removal and complications. Thus, I argue that third molars are **vestigial** and no longer provide an important function for people living in agricultural based societies where tooth wear and tear is highly reduced from what is found in modern hunter-gatherer and archaic human populations.

Introduction

Wisdom teeth, also known as third molars, are one of the last sets of teeth to develop in the human body (Pillai 2015). Third molars begin to rupture at 18 to 23 years of age (Pillai

2015); however, third molars begin development at 5 to 7 years of age (Kandasamy et al. 2009). In addition to the age of wisdom tooth development, there are several growth patterns that are commonly associated with third molars. One growth pattern includes a tooth encased within the bone, also known as **complete impaction** (Hatem et al. 2015). In *Figure 1*, two panoramic radiographs display a case of (A) underdeveloped impacted third molars and a case (B) where the impacted third molars are further developed, but one- third molar is removed (Figure 1). According to Pillai, a few of the more serious complications involved with impacted wisdom teeth include; soft tissue or bony lesions, loss of bone density, and infection or cysts (Pillai 2015). One of the more serious complications Kandasamy discusses is overcrowding of the jaw, which leads to the disruption of neighboring molars and teeth (Kandasamy et al. 2009). *Figure 3* evaluates the amount of overcrowding third molars create in comparison to erupted third molars (Figure 3). *Figure 3* also identifies the development of third molars (Figure 3). Wisdom teeth also develop outside of the bone, known as **complete eruption**, which occurs less frequently today. Erupted and impacted third molars frequently display **dental caries** and **deep pocketing**, both of which are two minor, often treatable complications (Silvestri & Singh 2003).

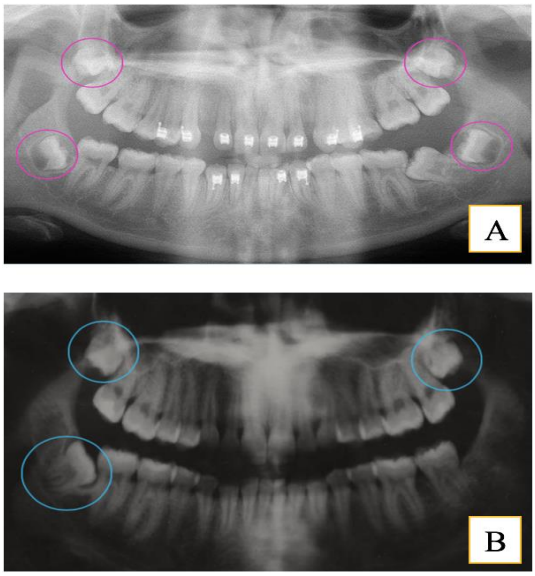


Figure 1. Two panoramic radiographs display impacted third molars. (a) displays four impacted third molars; (b) displays three impacted third molars after 4 years of development and extraction of fourth third molar. **(Images taken of Jade Barreto), (Courtesy of Dr. Mark Frizzo D.D.S. & BFOMFS)**

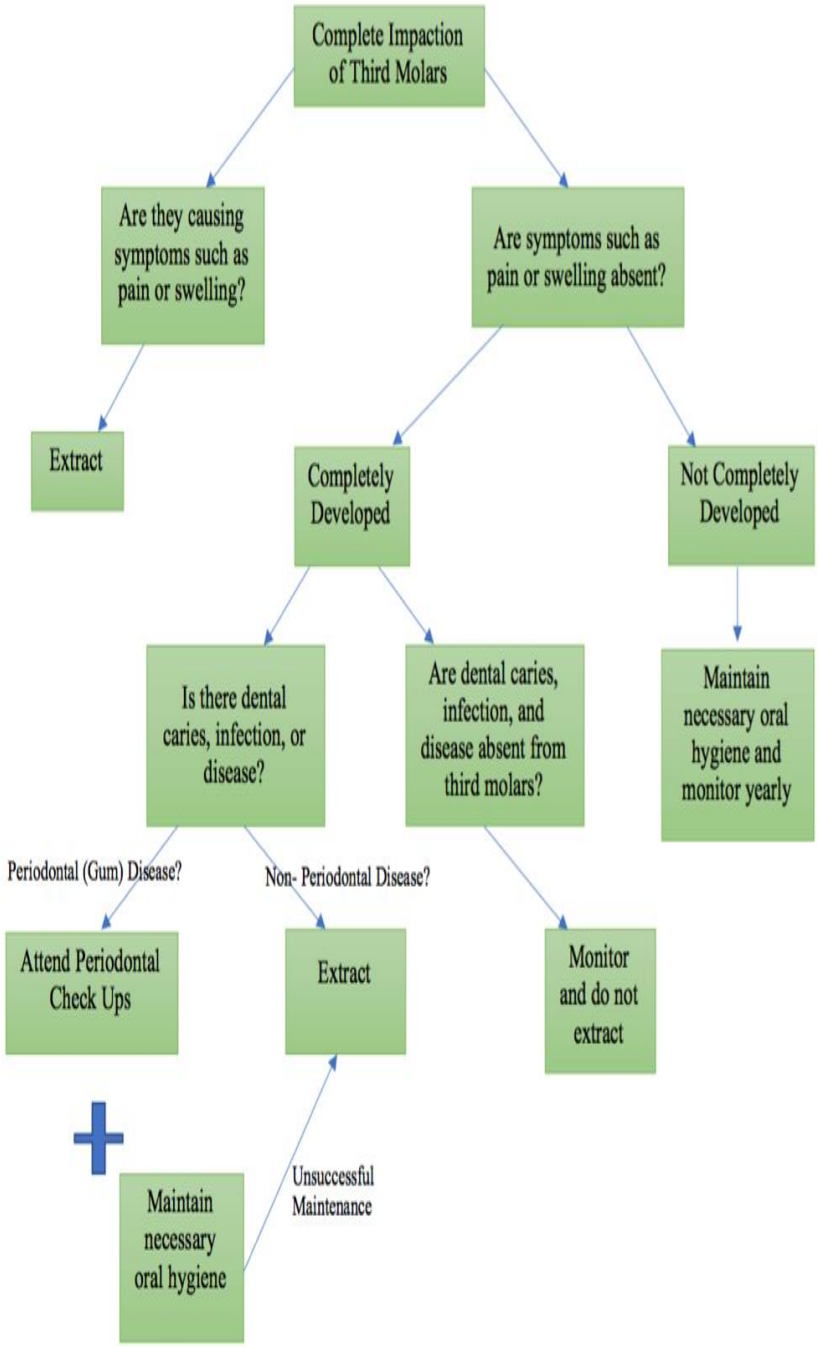
Likewise, many specialists in the dental field still debate the benefits and risks of surgical removal of impacted third molars. Dentists, as well as surgeons, must evaluate whether the wisdom teeth are causing their patients symptoms or not (Box 1). **Asymptomatic** third molars do

not present symptoms of pain, swelling, or infection (Kandasamy et al. 2009). Thus, if the patient's teeth are asymptomatic, the dentist or surgeon (after considering the patient's age) may deny surgical removal and instead recommend the patient to be re-evaluated in one- year or if symptoms develop (Kandasamy et al. 2009). On the other hand, **symptomatic** third molars present symptoms such as pain, inflammation, or infection. If the third molars are symptomatic, a dentist or surgeon will therefore recommend future removal (Kandasamy et al. 2009).

Box 1. Symptomatic vs. Asymptomatic Third Molar Eruption

Broadly speaking, there are two ways to distinguish third molars. One way to distinguish a set of third molars is if the tooth is encased within bone. A second way to distinguish a set of third molars is if the tooth is not encased within bone, and rather outside of the bone. When third molars are encased within bone, dentists or surgeons consider a few factors when determining whether to extract the third molars.

First, the dentists determine if the teeth are causing the patient any type of pain, swelling (intraoral or extraoral), infection, or bad odor. If symptoms are present, the most frequent recommendation is to extract the third molars. If symptoms are not present, then doctors investigate whether the teeth have formed their roots (completely developed), or if only the crown is present, meaning that the teeth are still developing. If the tooth is still immature, patients are recommended to wait and plan a future visit to re- check development. If the tooth is developed, doctors must determine if the dental caries are large enough to consider extraction. If so, then the teeth are recommended to be



extracted. If the dental caries are not significant enough, then patients are recommended to monitor the situation. **(Flow chart modified from Kandasamy et al. 2009).**

Advantages and Disadvantages of Third Molars

There are numerous advantages and disadvantages that may be associated with third molars. In general, when individuals have larger jaws, they are better suited for accommodating their wisdom teeth, and therefore, tend to experience fewer complications (Silvestri & Singh 2003). Developing a larger jaw serves as an advantage for developing wisdom teeth because teeth are less crowded and can rupture freely. Also, individuals with developed third molars have additional chewing surface, which creates less stress on the jaw while chewing on more dense meat or plants. Meanwhile, individuals that have a smaller jaw have less space for third molars, creating potential complications. Individuals with smaller jaws have less chewing surface, creating a higher chance of stress on the jaw; this serves as a disadvantage for developing wisdom teeth.

There are also many factors that can contribute to the development of wisdom teeth. Two factors that play an important role in developing wisdom teeth include: the resources and diet of the individual. More specifically, if an individual lives in a population where they only have access to raw foods, and no access to a heat source to cook their food, that individual will demonstrate more **tooth wear** on their first and second molars; example, select Neanderthals. In comparison, if the person comes from a population where fire is used for cooking to soften raw foods, those individuals will display less tooth wear on their first and second molars; example, Hunters and Gatherers and farmers. Moreover, if oral hygiene is incorporated into an individual's lifestyle (brushing teeth & dental cleanings), individuals will experience less decay and potentially less wear and tear.

Evolution of Wisdom Teeth

Through analyzing the teeth of Neanderthals, anthropologists and researchers are able to determine the dietary nutrients Neanderthals consume throughout their lifetime. Many of the foods that Neanderthals consumed caused an extensive amount of wear and tear on their posterior and anterior teeth (Clement et al. 2012). Broadly speaking, Neanderthals consume food that is mainly raw, rigid, and tough (Clement et al. 2012). In addition, there is evidence which demonstrates that Neanderthals have larger teeth, larger **mandibular** bones, and completely erupted third molars (Palanza & Parmigiani 2016). However, fossils are rare, thus there is a small chance that discovered evidence of impacted third molars. Generally, Hunters and Gatherers share many of the same physical characteristics present in Neanderthals dentition. There is a lesser amount of wear and tear on the Hunters and Gatherers **occlusal surfaces** in comparison to other dental records (El- Zaatari 2008). Investigators have further discussed how Hunters and Gatherers evolved a less dense diet, which provides evidence that the jaw size of Hunters and Gatherers may have been affected.

Additionally, dentists and anthropologists analyze the dental records of modern *Homo sapiens* in comparison to fossils of Neanderthals and Hunters and Gatherers. Unlike the Neanderthals and Hunters and Gatherers, agricultural *Homo sapiens* do not exhibit a significant amount of wear and tear on their posterior teeth or place a great amount of stress on them (Todor et al. 2018). Less wear and tear of posterior teeth in agricultural *Homo sapiens* shows that there is a dramatic change in diet (Todor et al. 2018). The change in occlusal wear also indicates less consumption of dense nutrients and food softened by cooking with fire unlike select Neanderthals and Ancient Hunters and Gatherers (Bharathi et al. 2018). Todor et al. discovered that the jaw bones of modern *Homo sapiens* have decreased in size, signifying some change in evolution (Todor et al. 2018). Moreover, *Homo sapiens* have shifted from a larger mandible to evolving a smaller mandible by altering their dietary intake to increase softened foods, which

reduced the wear and tear of third molars. Therefore, due to the dietary shift, evidence suggests that agricultural *Homo sapiens*, no longer require third molars for functionality (Todor et al. 2018). This suggests that third molars are vestigial (Box 2). The decrease in mandibular size affects the development of third molars, therefore, some individuals never develop them (Bharathi et al. 2018). However, there is still discussion in regard to the inconsistency of third molar development which may be the result of mutations over time or genetics (Pillai 2015).

Box 2. What is a Vestigial Trait?

Vestigial describes a characteristic of a structure, such as an organ, which once provided a critical function to an organism, but no longer provides a vital purpose (Bharathi et al. 2018). Gingerich and colleagues (1990) discovered vestigial hindlegs in whales, which once had quadrapedal ancestors. Investigators identified remains of limbs and foot bones of *Basilosaurus isis*, which is an ancestor of the medium whale (Gingerich et al. 1990). Previous to this discovery, anthropologists documented evidence of the pelvis and partial remains of the femur (Gingerich et al. 1990). In the image to the right, Gingerich illustrates two of the ancestors of the whale. In modern whales, the hindleg is absent and would not provide a vital purpose. Thus, Gingerich et al., determined that the hindleg of whales is vestigial. However, in other animals such as a deer, their hindlegs are crucial. A deer is very reliant upon their hind limbs for locomotion and survival, thus, we cannot classify deer hind limbs as vestigial.

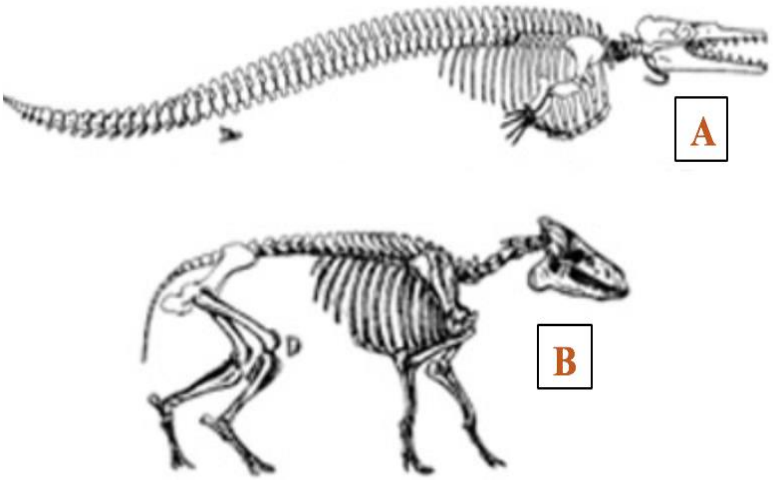


Image (A) illustrates the *Dorudon*, an ancestor of the whale (approx. 35 M.Y.A), with small foot bones. Image (B) illustrates the *Elomeryx*, an ancient ancestor of the whale (approx. 65 M.Y.A), with a pelvis and hindlegs.
(Images taken from Gingerich, P.D. 1990) (Dates estimated/retrieved from graph in Gingerich et. al 1990)

The evidence of third molars in agricultural *Homo sapiens* suggests third molars as vestigial, similar to the hindlimb in whales (Box 2). Third molars no longer provide an essential function (Todor et al.

2018). Additionally, dentists are observing how wisdom teeth are becoming more absent as time continues (Todor et al. 2018).

Neanderthal Diet

Neanderthals and modern *Homo sapiens* developed their wisdom teeth similar to one another (Clement et al. 2012). However, the reason for third molar development in Neanderthals is unique in comparison to agricultural *Homo sapiens* third molar development. Neanderthals developed third molars in order to offset the inability to completely breakdown **cellulose** and **masticate** (chew) raw meat (Bharathi et al. 2018). Fossils illustrate that Neanderthals diet includes fibrous and dense raw plants and meat (Bharathi et al. 2018). Clement et al. discovered that Neanderthals first and second molars have significant wear patterning on their teeth, which is a result of a coarse diet (Clement et al. 2012). Although third molars are the last set of teeth to develop, Neanderthals third molars still display a significant amount of wear. Additionally, evidence shows that Neanderthals have larger jaws, which allowed third molars to mature completely without disrupting surrounding teeth (Guatelli- Steinberg 2009). The overall dental arch of Neanderthals is larger in comparison to modern *Homo sapiens*, which is why Neanderthals have a larger jaw (Guatelli- Steinberg 2009). Researchers have not discussed the findings in use of fire in Neanderthals when discussing the dental fossils, thus, leaving the topic unclear.

Hunter and Gatherer Diet

Generally, Hunters and Gatherers display similar **dentition** and dietary intake of raw of under – cooked foods when compared to agriculturalists (Deter 2009). However, Hunters and Gatherers have an evolutionary change in dietary intake shown in their tooth erosion (Deter 2009). The transition in diet is evident because there is a lesser amount of tooth wear including

moderate occlusal wear on Hunter and Gatherer teeth (El- Zaatari 2008). This suggests that wisdom teeth are not vestigial in Hunter and Gatherer populations. Dental imaging identifies finite holes and scratches in Hunter and Gatherer dentition (El- Zaatari 2008). *Figure 2* displays images present in (A) Hunter and Gatherer dentition of one population (B) an agricultural population of Hunters and Gatherers from a second population (Figure 2). Moreover, when comparing fossils of earlier Hunters and Gatherers to the modern Hunter and Gatherer populations, researchers identified that the older Hunters and Gatherers presented more significant wear and tear in comparison to the agricultural generation (Deter 2009). Dental analysis indicate that Hunters and Gatherers consume a dense diet consisting of meat and plants (Deter 2009). On closer examination, however, Hunters and Gatherers mainly consume marine fish and sea turtles, plants and grasses, as well as lizards and pigs meat (El- Zaatari 2008).

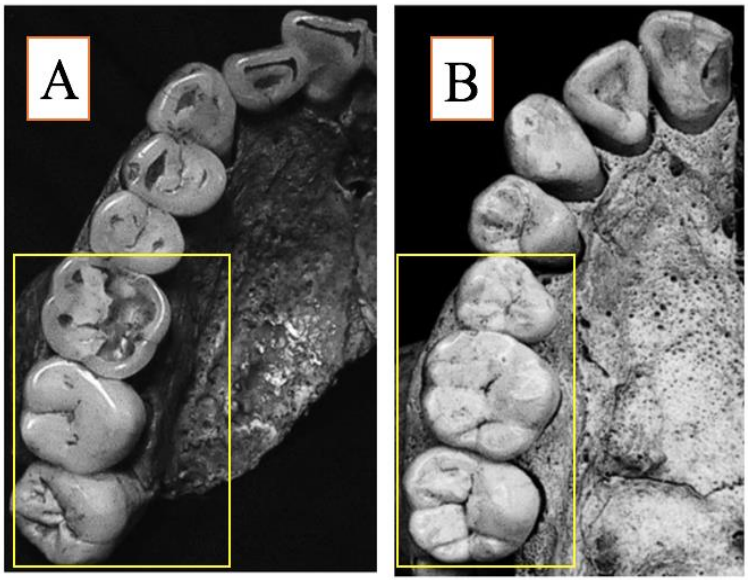


Figure 2. (A) represents a young male adult from the Indian Knoll population. In (A), the occlusal wear represents patterns of a hunter- gatherer population. (B) represents a young male adult from Hawikuh population. In (B), the occlusal wear is consistent with that of an agricultural population. **(Figure modified from Deter 2009)**

One feature in Hunter and Gatherer population includes the utilization of fire as a cooking source. Although Hunters and Gatherers incorporate fire for cooking, their food still remained tough because they consumed it half cooked and dried out due to inadequate knowledge of preparation (El- Zaatari 2008). In addition to the use of fire, Hunters and Gatherers designed tools out of stone, which allowed them to grind their food before consumption (Mahoney 2006). The utilization of fire as well grinding plants and meat are two features of

which became more common through time. Although there have been a few changes to dietary preparation, there is no specific research about how these changes have affected the jaw size of Hunters and Gatherers. More specifically, Hunters and Gatherers still consumed coarse nutrients which required high levels of mastication as well as enhanced chewing surface.

Agricultural *Homo sapiens* Diet

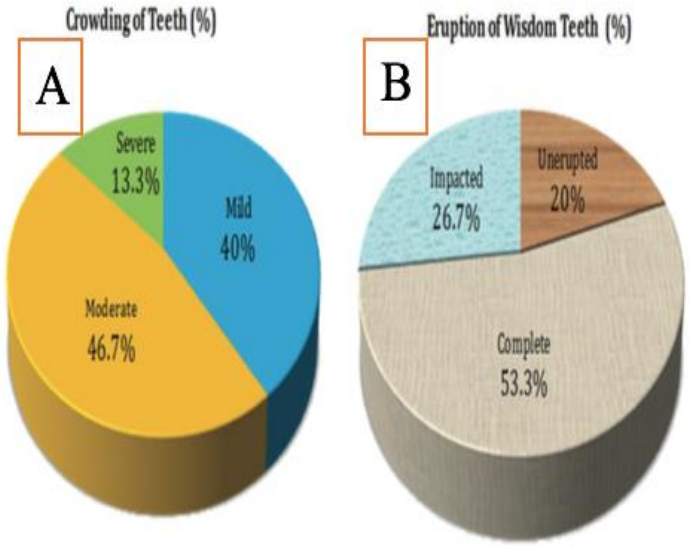


Figure 3. Third molar arrangement and positioning. (A) represents variation in alignment and crowding. (B) represents the percent of erupted wisdom teeth. **(Figure modified from Bharathi et al. 2018, Figure 3).**

Modern *Homo sapiens* have altered their development of third molars in comparison to australopithecines (Palanza et al. 2016). Silvestri and Singh have discovered a substantial change in diet as well as occlusal wear in modern *Homo sapiens*, suggesting wisdom teeth may now be vestigial (Silvestri & Singh 2003). In addition to reduced occlusal wear, evidence suggests that modern *Homo sapiens* require less chewing surface (Todor et al. 2018). *Homo sapiens* have transitioned from eating tough plants and raw/half – cooked meats to primarily softer and less dense food. Consumption of food has become simpler on the human body because modern *Homo sapiens* used fire to soften foods resulting in less grinding pressure. By cooking raw meat and raw plants, agricultural *Homo sapiens* have less wear and tear on their posterior teeth (Bharathi et al. 2018). The change in food preparation has initiated a significant change in jaw size of modern *Homo sapiens*. Silvestri and Singh measured a substantial decrease in mandibular jaw size, which lead to an increase in third molar impaction (Silvestri & Singh 2003). Moreover, not only are third molars

becoming more impacted, but **agenesis** of third molars is becoming more prevalent (Raloti et al. 2013) .

Evolutionary Shift of Third Molars in modern *Homo sapiens*

Pillai and Kumar (2015) argue whether the transition in diet and mandibular size has significantly affected the development of third molars in modern *Homo sapiens*. Furthermore, modern *Homo sapiens* no longer need wisdom teeth because they are no longer providing an essential function to us. Approximately 98 percent of wisdom teeth are impacted (Hatem et al. 2015). Additionally, impacted wisdom teeth can potentially cause dental caries and periodontal disease to occur (Bharathi et al. 2018). If left untreated, impacted or partially impacted wisdom teeth have the potential to cause inflammation and infection to occur (Renton & Wilson 2016).

Contrastingly, Guatelli-Steinberg (2009) argues that wisdom teeth may still provide an essential function to modern day *Homo sapiens* because they provided an essential function to Neanderthals. One of the advantages of having wisdom teeth is that they provide extra chewing power as well as surface area for chewing (Guatelli-Steinberg 2009). A second advantage to having third molars is that they provide a replacement for worn- down first and second molars. Moreover, due to poor oral hygiene or poor genetics, the third molars could act as a replacement for missing teeth (Guatelli- Steinberg 2009).

Discussion

Neanderthals dietary intake is very coarse and fibrous; however, select Hunters and Gatherers and agricultural *Homo sapiens* have transitioned to a softer and less dense diet. Research discusses how dietary consumption is one possible effect of occlusal wear in posterior teeth. Evidence suggests that there is more occlusal wear and tooth loss in Neanderthals and Hunters and Gatherers due to diet in comparison to minimal amounts of occlusal wear in modern *Homo sapiens*. As a result of diet change, the size of our jaw bones have been reduced. Modern

Homo sapiens present smaller mandibles and impacted teeth; whereas, Neanderthals present larger mandibles and erupted teeth.

Limitations

Many challenges arise while evaluating whether wisdom teeth are essential to our current time. Although we are able to observe changes in dentition and changes in dietary intake, the amount of information that is provided from ancient history limits our research. More specifically, we are limited to the fossil records in which we have access to from the time of Neanderthals and Hunter and Gatherer populations, leaving some information unknown. Modern-day information also limits researchers and dentists understanding of third molars. Another area of limitation is that many of the articles focus only on the dentition of teeth, rather than anthropological information that may also correlate to the dentition such as fire and tools. Additionally, obtaining evidence from close relatives, chimpanzee and gorillas, of modern *Homo sapiens* is very limited due to limited fossil evidence. Hence, there is not enough evidence to determine whether or not this pattern will continue to happen, or whether time will repeat itself. I argue that we will continue to see a disappearance in wisdom teeth in modern populations, however, history is not always predictable.

Conclusion

Recent investigation of third molars has allowed dentists and anthropologists the ability to determine that wisdom teeth provided an essential function in Neanderthals and in Hunters and Gatherers of our species. However, due to increased rate impaction and infection, agricultural humans are decreasing their functionality of third molars and increasing symptoms. The shift in functionality has allowed many to argue that our species is constantly evolving, and will continue to evolve as time goes on. The shift in large mandibles and wisdom teeth to small mandibles and absent wisdom teeth shows how different the diet of our ancestors were in

comparison to modern agricultural diet. The dental and anthropological evidence that accumulates overtime will ultimately determine whether third molars are vestigial.

Glossary Box.

Agenesis: Occurs when a tooth is unable to develop. More specifically, the teeth will not develop at any point in lifetime.

Asymptomatic: A type of eruption that occurs with no symptoms involved.

Cellulose: a type of plant that a human is unable to digest completely.

Complete Eruption: A dental development pattern that occurs when the tooth is not encased within the bone, but rather is outside of the bone above the gum tissue.

Complete Impaction: A dental development pattern that occurs when the tooth is incased within the bone and is not able to fully erupt outside of the bone.

Deep Pocketing: Occurs when the gum tissue becomes looser around a tooth and creates a pocket for debris to reside.

Dental Caries: "Dental cavities" when occurs when the bone begins to loose density due to genetics, poor dental hygiene, or friction of surrounding teeth.

Dentition: The arrangement and structure of teeth.

Mandibular Jaw Bone: The bottom jaw bone of the mouth. The human body is made up of the Maxillary Jaw Bone and the Mandibular Jaw bone which join together to allow an individual's mouth to open and close.

Masticate: Chewing

Occlusal Surface: "Chewing surface"; The flat surface where the top teeth of your mouth meet the bottom teeth of your mouth.

Symptomatic: A type of eruption that occurs with symptoms such as pain, swelling, infection are involved.

Vestigial: A structure which once provided an important function, but no longer serves an essential function.

Tooth Wear: Occurs when animals chew on dense material which causes teeth to have a flat chewing compared to a chewing surface that has grooves.

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