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Analysis of Lower Third Molar Eruption in Chinese Females Throughout the Holocene

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ABSTRACT

Objective: To analyze lower third molar (M3) eruption and changing trends among Holocene female populations in China. Methods: M3 was categorized into 3 types: full eruption, full impaction and/or absence, and partial impaction. We compared M3 eruption rates of the three types across the Holocene eras (48 samples from the Neolithic Age; 128 samples from the Bronze and Iron Age; and 26 samples from the Present Age) to look for changing trends. Results: The rate of fully erupted M3s has steadily declined over time, while the prevalence of fully impacted and/or absent M3s has increased. Conclusion: The decline in the frequency of fully erupted M3s throughout time may be linked to the evolution of more refined diets and less robust masticatory organs.

Keywords: holocene *population,; lower third molar eruption, masticatory organs, m3 impaction, tooth anatomy; tooth morphology, dental anthropology*

Introduction

Throughout human evolution, changes in food structure have caused the masticatory apparatus to reduce and degenerate in an uneven way, starting with the masticatory muscles, then the jaw, and finally the teeth[1]. It is commonly assumed that deterioration and shrinkage of the jaw affect the morphology of the upper and lower teeth. Third molars, also known as wisdom teeth (hereinafter referred to as M3), are the last permanent teeth to erupt and have the highest prevalence of agenesis. M3s also exhibit significant morphological variations, and they are characterized by the variation in their formation time across populations. However, few studies have been conducted on the topic of M3 eruption over time in Holocene populations (the broad term for populations from the Neolithic to the present). Dai examined lower M3 eruption over time in Holocene males[2]. This study, on the other hand, used the lower M3s of Holocene females as the research material to thoroughly analyze their eruption, how they have changed through time, and the possible causes of these changes.

Materials and Methods

Materials

In this study, the mandibles of a total of 202 Holocene Chinese females as research materials were investigated. Out of the total, 48 belonged to the Neolithic era, 128 to the Bronze and Iron ages, and 26 to the modern era. Materials from the Neolithic period were excavated from the Jiangjialiang site in Yangyuan, Hebei, Xishan in Zhengzhou, and Miaozigou in Inner Mongolia. Materials from the Bronze and Iron ages were excavated from the Lamadong site in Liaoning, the Tuchengzi site in Inner Mongolia, the Xiaohandi and Mapai sites in Minhe, Qinghai, and the Longxian site in Shanxi. Materials from the present age were mainly sourced from the current North Chinese populations. Research materials have been preserved and stored at the Research Center for Chinese Frontier Archaeology of Jilin University and the Institute of Vertebrate Paleontology and Paleoanthropology. Research materials in this study related to people who died at a very old age or were too young were not used. For archaeologi-

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cal background information related to the aforementioned sites, please refer to Li et al[3].

Methods

Referring to the studies of Shao[4] and Dai[2], the morphology of M3 in this study was categorized into three types: full eruption, full impaction and/or absence, and partial impaction (Figure 1), as follows:

(i)Full eruption means that the third molars erupt completely and properly from their position as usual and are about the same size as the second molars (M2s).

(ii)Full impaction indicates that M3s are completely hidden underneath the gum tissue and are unable to erupt through the gumline at all. The absence of M3s suggests that individuals are born without them.

(iii)Partial impaction shows that M3s partially break through the gumline while remaining partially underneath the gum tissue, including nail-type teeth, incomplete eruption, impaction, etc.

To determine the dental morphology of M3s, the M3 eruption condition was first assessed on the left and right sides of the mandibular bones, and then percentages for each morphological category were calculated. Next, the significance test (Z score calculus) was applied to determine the statistical significance of M3 eruption rates of the three types across the Holocene eras, with results deemed significant for $|Z|>1.96$ and $P<0.05$ as calculated using the following formula[5]:

$$Z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\frac{\left(n_1\hat{p}_1 + n_2\hat{p}_2\right)\left(n_1\hat{q}_1 + n_2\hat{q}_2\right)}{n_1 n_2\left(n_1 + n_2\right)}}}$$

Results

Comparisons of M3 eruptions in Chinese females across the Holocene eras

Comparisons of M3 eruptions in both Chinese females and males across the Holocene eras are shown in Table 1. Left M3s fully erupted at a rate of 69.1 percent during the Neolithic Age, 54.5 percent during the Bronze and Iron Ages, and 38.5 percent during the Modern Era, demonstrating a reduction in the frequency of fully erupted left M3s with time. The test of significance showed a substantial difference between the Neolithic and contemporary ages.

Left M3s were fully impacted and/or absent at a rate of 26.2 percent during the Neolithic Age, 35 percent during the Bronze and Iron Ages, and 50 percent during the Modern Era, indicating an increase in the frequency of fully impacted and/or absent left M3s over time. The test of significance showed a statistically significant distinction between the Neolithic and modern periods. Left M3s were partially impacted at a rate of 4.8 percent during the Neolithic Age, 10.6 percent during the Bronze and Iron Ages, and 11.5 percent during the Modern Era, indicating an increase in the frequency of partially impacted left M3s with time. The test of significance revealed that the variations between the Neolithic and contemporary ages were insignificant.

Right M3s fully erupted at a rate of 73.3 percent during the Neolithic Age, 59 percent during the Bronze and Iron Ages, and 34.6 percent during the Modern Era, demonstrating a decline in the frequency of fully erupted right M3s with time. The test of significance showed a major distinction between the Neolithic and current ages. Right M3s were fully impacted and/or absent at a rate of 24.4 percent during the Neolithic Age, 31.2 percent during the Bronze and Iron Ages, and 57.7 percent during the Modern Era, showing an increase in the frequency of fully impact-

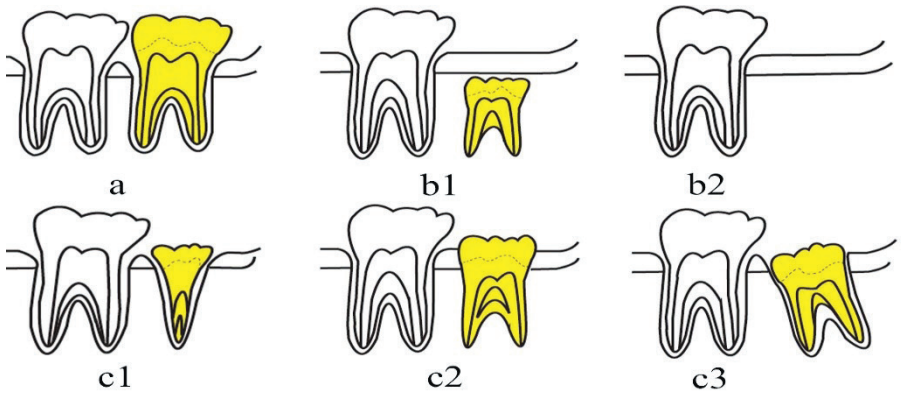

Fig. 1. Morphologic classification of M3 and comparison with normal M2. (White is normal M2, dark is different morphology M3). a) Full eruption b) Absence c) Partial impaction (a is full eruption; b1 is not eruption; b2 is completely absence; c1 is nail-type teeth; c2 is incomplete eruption; c3 is impaction). Note: The figure is modified according to the literature20

TABLE 1

COMPARISON OF HUMAN MANDIBULAR M3 IN DIFFERENT AGES OF HOLOCENE

		Neolithic				Bronze-Iron				Present				Z					
		Male		Female		Male		Female		Male		Female		Male			Female		
		n	%	n	%	n	%	n	%	n	%	n	%	Neolithic-Bronze-Iron	Bronze-Iron-Present	Neolithic-Present	Neolithic-Bronze-Iron	Bronze-Iron-Present	Neolithic-Present
Total		54		42		187		123		112		26							
Left M3	full eruption	41	75.9	29	69.1	122	65.2	67	54.5	58	51.8	10	38.5	-1.48	-2.3*	-2.97*	-1.65	-1.48	-2.48*
	absence	12	22.2	11	26.2	47	25.1	43	35.0	38	33.9	13	50.0	0.44	1.63	1.54	1.05	1.44	2*
	partial impaction	1	1.9	2	4.8	18	9.6	13	10.6	16	14.3	3	11.5	1.87	1.23	2.48*	1.13	0.15	1.04
Total		54		45		189		122		111		26							
Right M3	full eruption	39	72.2	33	73.3	121	64.0	72	59.0	58	52.3	9	34.6	-1.12	-2.01*	-2.45*	-1.7	-2.27*	-3.2*
	absence	13	24.1	11	24.4	47	24.9	38	31.2	32	28.8	15	57.7	-1.12	0.75	0.64	0.84	2.56*	2.8*
	partial impaction	2	3.7	1	2.2	21	11.1	12	9.8	21	18.9	2	7.7	1.64	1.88	2.65*	1.63	-0.34	1.1

*means $|Z|>1.96$, $P<0.05$

Note: The statistics of Holocene males were quoted in the literature[2]

ed and/or absent right M3s over time. The test of significance showed a significant distinction between the Neolithic and modern periods. Right M3s were partially impacted at a rate of 2.2 percent during the Neolithic Age, 9.8 percent during the Bronze and Iron Ages, and 7.7 percent during the Modern Era. The test of significance showed no major differences between the Neolithic and contemporary ages.

According to the findings in Table 1, the eruption rates and morphological features of left M3s and right M3s in Holocene female populations are generally identical.

Discussion

Differences in M3 eruptions between sexes

Some researchers have examined gender variations in M3 eruptions, with varying results. Hattab[6] analyzed M3 eruption in 36 (19 males and 17 females) undergraduates from the Department of Oral Radiology at the Jordan University of Science and Technology. He found that the M3 impaction rate was 28.2 percent higher in the maxillary than the mandible, but there was no gender difference. Based on data from 571 healthy Jordanian teenagers, Ashraf et al[7] came to the conclusion that there was no big difference between boys and girls when it came to M3 eruption. In another study, Arsène et al[8] examined 557 people (340 men and 217 women) in a hospital affiliated with a French university. They compared the morphological variations of M3s at every stage of eruption and found no significant differences between men and women.

Nevertheless, research results obtained by Chen et al. showed that the M3 eruption rate was higher in men than in women[9], which is consistent with the views of Zhou[10] and Nie[11]. Furthermore, Zhang et al[12] examined M3s of 1446 Han people aged 18–38 (562 males and 884 females) in Longjiang Town, Zizhong County, Sichuan Province, China, and discovered that the M3 impaction rate (defined herein as teeth that partially or completely failed to erupt) was significantly higher in females than in males (68.64 percent in females and 31.37 percent in males). Abbas et al[13] studied a total of 1,650 patients (629 males, 921 females) at the Orthodontics Department of Hamadan Dental School in Iran in 2012 and 2013 and found that more women than men had impacted mandibular M3s.

Differences in the age of M3 eruptions across populations

Studies have shown that there are differences in the age of M3 eruptions among different populations. For example, Fanning looked at M3 eruptions in white people in Boston, USA, ages 13 to 22 (2,370 men and 10,053 women). She found that the average American male and female maxillary M3 eruption ages were both 20.5 years, while the average male mandibular M3 eruption age was 19.8 years and that of females was 20.4 years[14]. In another study, some 13-year-old African boys' M3s had begun to erupt, and by age 20, M3s of the majority of boys (75 percent) had all erupted[15]. Garn et al[16] studied M3 eruptions in 953 black and 998 white people in the United States and discovered that black maxillary M3 eruptions occurred 3.7 years earlier than whites, while black mandibular M3s erupted 5.6 years earlier. In other work, Caldas et al[17] analyzed X-rays of Portuguese residents (264 males and 257 females aged 6–22 years) and found that in males, the minimum age for both fully erupted upper and lower third molars was 13.4 years. In females, the lower third molars were fully erupted by the time they were 15.9 years old.

Liu et al[18] indicated that the congenital absence of M3 in China is characterized by a unique chronological continuity, while this feature is also important evidence reflecting the evolution of ancient humans in China. Gou et al[19] looked at photos of 1,135 people in northern China (506 men and 629 women) and found that the age of M3 eruption was younger in men than in women. For example, the average age at which M3 fully erupted in males from northern China was 22.9 years, which was similar to what was found in South Africa. However, this result was different for different groups. For example, full M3 eruptions were reported to happen 0.5 years earlier in Japanese subjects and 0.5 years later in German subjects when compared to Chinese subjects. Meanwhile, the average age at which M3 fully erupted in females in northern China was 22.8 years, an age that was 0.5 and 0.8 years older than that of Japanese and South African subjects, respectively, but 1.2 years younger than German subjects. Furthermore, the results of that study revealed that mandibular M3s of northern Chinese residents erupted before maxillary M3s, which were in line with those reported for some Jordanians7 , Japanese men[20], Canadian Aboriginal men[21], Australian aboriginal men[22], Negroes in the United States[23], and Croatians[24], but were in contrast to those obtained for German males[25]. These findings show that M3 eruptions may happen at different times and have different shapes in different populations.

Influencing factors of M3s morphology

It is widely assumed that as human evolution progressed, with the advancement of technology and the refinement of food, human masticatory organs increasingly degraded, and M3 eruptions evolved appropriately. These modifications are influenced by genetic and environmental variables, as well as perhaps the impacts of race, gender, dietary habits, chewing function, illness, etc. For example, Hong et al[26] found that the M3 impaction rate (22 percent) of the Naxi people in Yunnan was lower than that of the Han people (29.5 percent). One possible explanation is that the Naxi diet is predominantly comprised of dry and hard foods, which necessitates an extreme amount of chewing over a lengthy period of time and hence contributes to the growth of the jaw. In another study, Chen et al[27] investigated the M3 eruptions of 836 college students nationwide and found no obvious differences in M3 eruption rates in terms of living in both urban and suburban

areas. In addition, they found that the M3 eruption rate in college students in northwest China was significantly lower than that in other regions.

Meanwhile, studies show that some morphological aspects of the mandible itself are closely related to the M3 eruption. One of the most critical elements influencing M3 eruption status has been identified as the molar posterior space[28]. Furthermore, Bjork et al discovered that insufficient posterior M2 space was linked to 90 percent of M3 impaction. The length of the mandible is also considered to be one of the factors affecting the M3 impaction[29,30]. However, the conclusion isn't agreed upon by everyone. For example, Kaplan[31] and Dierkes[32] suggested that the length of the mandible had little connection with the rate of M3 impaction. In addition, a more recent study found that the mandibular M3s were prone to being impacted when the angle of the mandibular plane was smaller[33] .

Features and factors associated with the M3 eruptions across Holocene eras in China

In this study, we compared the mandibular M3 eruption in females across different eras and concluded that M3 showed a clear trend of full impaction. After comparing with the data in males2, we found that the rates of fully erupted and fully impacted (absent) left and right M3s in males and females showed similar trends over time from the Neolithic Age to the present age: the rate of fully erupted M3s decreased over time while the rate of fully impacted and/or absent M3s increased.

By comparing the data to what Dai et al. found (Table 1) and looking at both the left and right M3s separately, we found that the rates of M3 eruption were different for the three types of eruption depending on the age of the person and the gender. For the left M3s, in terms of the left M3 full eruption, changes in M3s between the Bronze and Iron Age and present age and between the Neolithic Age and present age were significant for males, whereas only differences in M3s between the Neolithic and present age were significant for females; for men, there was no statistically significant difference in the left M3 full impaction and/or absence between time periods. For women, however, there was only a difference between the Neolithic and modern time periods; and in terms of left M3 partial impaction, there was a big difference between the Neolithic and the present day for men, but there wasn't a major difference across eras for women. For the right M3s, when it came to the full eruption of the right M3, both males and females showed the same eruption rate; there were major differences between the Bronze Age and the Iron Age, and between the Neolithic Age and the present day; when it came to the right M3 full impact, there were no big differences between eras for men, but there were big differences between the Bronze and Iron Ages and the present and between the Neolithic Age and the present for women; and when it came to the right M3 partial impaction, there was a significant difference between the Neolithic and present age for males, but no significant difference between different eras for females.

Several scholars have studied the causes of the decline in the frequency of fully erupted lower M3s in the Holocene populations. Liu et al[34] suggested that the rate of jaw bone degeneration has been faster than that of the teeth during human evolution, and that the jaw doesn't have enough space for the teeth to erupt and grow, which causes wisdom teeth to become impacted and/or absent. It has also been suggested that the decrease in the size of the mandible over time is the main reason for the increase in the rate of M3 full impaction and absence[2]. The factors contributing to Holocene mandibular evolution on a microscopic scale have also been investigated. According to Li et al[1], the Holocene era was marked by significant climate change, and these changes also caused some ecological changes that had an impact on human food sources. Food processing technology advanced during the Neolithic to Bronze-Iron Ages along with changes in human social production tools and the growth of productivity. As a result, the capacity to chew weakened as food became softer. Human life has improved and the impact of food has considerably decreased from the Bronze-Iron Ages to the present, while the size of the mandible has evolved to shrink over time. The reduction of the mandible may have been caused, directly or indirectly, by the variables listed above, according to Li et al[1].

Incorporating previous perspectives and this paper's findings, the researchers suggest that the climate has changed more since the Holocene, and that with the change in production tools and productivity, food has become softer and chewing strength has decreased; consequently, the stimulation of mandibular development has decreased, leading directly or indirectly to the diminution of mandible size. The post-molar gap has shrunk due to the smaller mandible, which has also compressed the position of the teeth and reduced the rate of full eruption.

Conclusions

According to this study, the findings indicate that the eruption rates and morphological features of lower left M3s and lower right M3s in Holocene female populations are nearly equal. Compared with the data on males, we found that the rates of left and right M3 full eruption and full impaction in both males and females changed in the same way from the Neolithic Age to the present age: the rate of fully erupted M3s has declined over time, while the prevalence of fully impacted and/or absent M3s has increased. Based on the results, we hypothesized that the gradual drop in fully erupted M3s through time may be related to the development of more refined diets and less powerful masticatory organs.

Recommendations

This study can offer useful information on the mandibular M3 eruption in Chinese Holocene females and the reasons behind variations in these eruptions over time. It also has modern medical significance in that the under-

standing of the third molar's morphology makes it easier to make an initial diagnosis, which helps with clinical extractions and, to a certain extent, helps with orthodontic treatment. Furthermore, as current technology advances, more accurate measurements can be achieved if CT scans and other technologies are employed later.

Limitations

The main method used in this study to evaluate whether M3s were absent was visual observation, which has the drawback of misclassifying an M3 as "missing" when it is actually buried and not yet erupting from the socket. The use of a probe to open the mandibular sulcus or an X-ray or CT scan can be more accurate, but these methods are either destructive or costly. The percentage of embedded teeth was low, and the observation was conducted using a consistent standard, therefore there was little impact on the findings.

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ANALIZA ERUPCIJE DONJEG TREĆEG KUTNJAKA U KINESKIH ŽENA TIJEKOM HOLOCENA

SAŽETAK

Cilj rada je analizirati erupciju donjeg trećeg kutnjaka (M3) i trendove promjena tijekom holocena u ženskim populacijama u Kini. M3 je kategoriziran u 3 vrste: potpuna erupcija, potpuna impakcija i/ili odsutnost te djelomična impakcija. Usporedili smo stope erupcije M3 kroz 4 holocenska razdoblja od neolitika do današnjeg doba. Rezultati pokazuju stalan pad učestalosti potpuno eruptiranih M3 i stalan rast potpuno impaktiranih i/ili odsutnih M3, što se može povezati s evolucijom profinjenijih načina prehrane i manje robusnih žvačnih organa.