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Enamel hypoplasia in a Mesolithic (5900±100 BC) individual from Woźna Wieś (Poland): a case study

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Abstract: Modern anthropological research includes very sophisticated diagnostic methods. They allow us to obtain information that has not been available so far. The aim of this paper is to analyze, using current microscopic technologies, the Mesolithic dental material of one adult individual from Woźna Wieś (Poland). The present case study will focus on the analysis of enamel hypoplasia. A scanning electron microscope (SEM) was used to count the number of perikymata building on the hypoplastic line. Linear enamel hypoplasia (LEH) was diagnosed only on the right mandibular canine. The time of occurrence of environmental disturbance was estimated between about 4.2 and 4.9 years of age. The occlusal wall built the enamel hypoplasia with no more than three to four perikymata, meaning that the physiological stress had to have occurred over a fairly short period of time (about 30–40 days).

Key words: Mesolithic, Woźna Wieś, enamel hypoplasia

Introduction

Getting to know the health conditions, level of hygiene, and dietary habits of human groups is a fairly common objective of bioarchaeological studies (e.g., Šlaus et al. 2011, Tomczyk 2016, Gamble et al. 2017). In this way, we can draw conclusions about the lifestyles of populations in historical periods. The source of this information is the assessment of physiological stress indicators. Poor living conditions cause a reaction of the body, which can manifest in the bone (e.g., *porotic hyperostosis*, *cribra orbitalia*, Harris lines, body height) (e.g., Piontek and Kozłowski 2002, Sullivan 2005, Liebe-Harkort 2012) and/or dental material (e.g., enamel hypoplasia, dental caries, periodontal disease) (e.g., Berbesque and Hoover 2018, Tomczyk et al. 2018). The assessment of physiological stress on bone material is important, but due to the high fragmentation of bioarchaeological material it is not always possible to test these stress indicators (e.g., Piontek 1999, Keenleyside and Panayotova 2006). Since dental material is usually

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well preserved in archaeological sites, studies of such material are frequently used in anthropological investigations (e.g., Berbesque and Doran 2008, Jackes 2009, Gamble et al. 2017).

One of the areas of odontological research that provides information on past and contemporary populations is the study of enamel hypoplasia, because enamel is the hardest biological substance and does not remodel once formed (e.g., Hillson 2008, 2014). Enamel hypoplasia is the most common irregularity observed in teeth and is expressed as lines, grooves, or pits resulting from reduced functioning of the ameloblasts and a consequent failure in the formation of the enamel matrix (Hillson and Bond 1997, Herring et al. 1998, Hillson 2008, Witzel el al. 2008). The most commonly studied type of defect appeared as a horizontal line (groove), called a linear enamel hypoplasia (LEH). From the point of view of bioarchaeological studies, LEH seems to be the most interesting type of hypoplasia, because the location of the LEH makes it possible to establish the age at which these defects occurred (e.g., Ritzman et al. 2008, Pêtersone-Gordina et al. 2013, Smith et al. 2016).

Enamel hypoplasia is treated as a nonspecific indicator of stress, but, even so, many authors consider it the most reliable tool in anthropological research (e.g., Tomczyk et al. 2012, Guatelli-Steinberg et al. 2014, Smith et al. 2016). As we know, its analysis enables a reconstruction of the level of health and, indirectly, also the economic and social status of the examined population. These studies reveal a general tendency that populations living at a high social level show, on average, a lower prevalence of enamel hypoplasia than communities in poor living conditions (e.g., Nakayama 2016, Ungar et al. 2017). High socio-economic status is associated with a healthy diet, good medical care, and proper living conditions. In contrast, poverty is associated not only with malnutrition, but also with poor hygiene and more frequent and more serious diseases.

Enamel hypoplasia is also interesting in the registration of changes that occurred during the transformation from the hunter–gatherer to the agricultural society. Generally, it can be noticed that along with the change in the functioning of the community in the historical material, the prevalence of enamel hypoplasia increases (Krenz-Niedbała and Kozłowski 2013, Temple 2010, Tomczyk et al. 2012, Berbesque and Hoover 2018). In this context, each study on Mesolithic dental material is important and interesting, because it allows us to get to know the living conditions of the pre-agricultural community. Unfortunately, human remains dating back to the Mesolithic period in Poland are quite rare and fragmentary (e.g., Kozłowski 1998, Stanaszek and Mańkowska-Pliszka 2015). Thus, our knowledge about this historical period is still very modest.

The aim of this paper is to analyze the Mesolithic dental material from Woźna Wieś (Poland). This Mesolithic site was discovered over 50 years ago and has been previously studied using the macroscopic methods that were available then. Unfortunately, the findings were never published. The present study will focus on the analysis of enamel hypoplasia using modern microscopic technology.

Material

The paper concerns the dental material from a Mesolithic site in northeastern Poland, Woźna Wieś. The human remains were discovered in 1961 in Woźna Wieś, a village near Dręstwo Lake, from which the Jegrznia River flows, belonging to the Elk Lakeland (53^{0}40′53″N 22^{0}45′06″E) (Sulgostowska 1990) (Fig.1). The material was deposited at the State Archaeological Museum in Warsaw.

The traces of a settlement were found in the lakeside arable fields 500 m from the Jegrznia River exit. In addition to abundant flint artifacts, the presence of moose and reindeer in Alleröd was found, as well as the remains of subsequent forest animals (bison, deer, sheep, and horses) and human bones. A chronological analysis was conducted using the ^{14}C method, which dated these remains to about 5900±100 BC (Sulgostowska 1990).

However, the bone material from Woźna Wieś was very fragmentary, containing only fragments of the human cranium and 14 permanent teeth. The dental material belonging to this individual was as follows (numbered according to FDI 1971): upper second incisor (22), upper first (14) and second premolars (15, 25), upper first (26) and second (17) molars, lower first incisor (41), canine (43), both first premolars (44, 34), and first (36), second (37), and third (38, 48) molars (Fig. 2).

Diagnosis of sex and estimation of the age at death were impossible. However, according to the radiograph pictures, it was possible to estimate the dental age. With this aim, the Drusini method (2008) was used. This method was chosen because it is a noninvasive technique, contrary to others, which require microscopic preparation of teeth (Gustafson 1950, Dalitz 1962, Maples 1978). According to this method, only the mandibular premolars and molars were considered. Panoramic radiograph was used

Fig. 1. Location map of the study area

Fig. 2. Mesolithic dental material adult from Woźna Wieś

to measure the length of the tooth crown and the length of the coronal pulp cavity. The tooth–corona index was computed for each tooth and regressed on the dental age of the individual. According to the Drusini method, the dental age of the individual from Woźna Wieś was estimated at about 26–30 years.

Methods

Dental enamel was observed with a CL-D 10x magnifying glass with an additional source of light. Generally, hypoplastic defects are classified into six groups: – 0: healthy enamel; 1 and 2: opacity on the surface; 3: pits; 4: horizontal grooves and/or lines (LEH); 5: vertical grooves and/or lines; and 6: missing enamel on a certain part of the surface (FDI 1982).

Crown height was measured with a caliper (0.01 mm) from the cemento–enamel junction (CEJ) to the apex on the vertical plane bisecting the labial surface of the teeth. Also, the distance from the CEJ to the start of the defect was measured. These measurements were converted into the approximate ages of development based on the timing of enamel formation.

Reid and Dean (2000, 2006) built developmental charts for each tooth type, where teeth are divided into 10 different regions (deciles) from cusp to CEJ, and age range charts are useful for estimating developmental age across the tooth crown. This method involves the allocation of hypoplastic defects within a broad developmental phase (the rate of enamel growth is not constant but decreases from the tip to the cervical margin), and it eliminates the need to correlate the specific age with any given hypoplastic defects. Reid and Dean (2000, 2006) proposed crown growth models for different populations, both contemporary and historical. One set of age reconstructions is derived from a Northern European sample containing individuals from the medieval site of Tirup. Due to the location of our sample from Woźna Wieś, we decided to use the standards for this population (Reid and Dean 2006).

In addition, scanning electron microscope (SEM) analysis was used for counting the number of perikymata to assess the duration of physiological stress. In our observation, we used SEM-FEI Quanta 200 at a magnification of 60x to 200x, which is considered the standard procedure (e.g., Guatelli-Steinberg 2008). The total number of perikymata from the occlusal wall was counted. These perikymata actually reflect the period of disrupted enamel growth, while the cervical wall corresponds to a return period to normal enamel growth. According to the authors (Fitzgerald and Rose 2008, Guatelli-Steinberg 2008), the perikymata were built, on average, every 8–10 days, which means that, based on the number of perikymata from the occlusal wall, we were able to estimate the average time of disturbance of ameloblast secretion.

Results

LEH was diagnosed only in one case, in the lower canine (43) of the individual from Woźna Wieś. The height of the canine crown was 9.1 mm. However, the canine crown showed serious wear (no. 5 according to Smith's scale, 1984). Therefore, to estimate the total height, the mean crown height was used as proposed by Reid and Dean (2006). The distance from the CEJ to the start of the enamel defect (i.e., length of the normal enamel) was 2.0 mm and from the CEJ to the top of the enamel defect was 2.7 mm. This means that the defect width was a maximum of 0.7 mm. According to developmental standards (Reid and Dean 2006), the defect appeared between the ages of 4.2 and 4.9 (Fig.3).

In this case, the LEH from the occlusal wall was built by three to four perikymata, meaning that the physiological stress had to have taken place over a fairly short period of time (about 30–40 days) (Fig.4).

Fig. 3. Pictures of lower canine with estimation time of enamel development

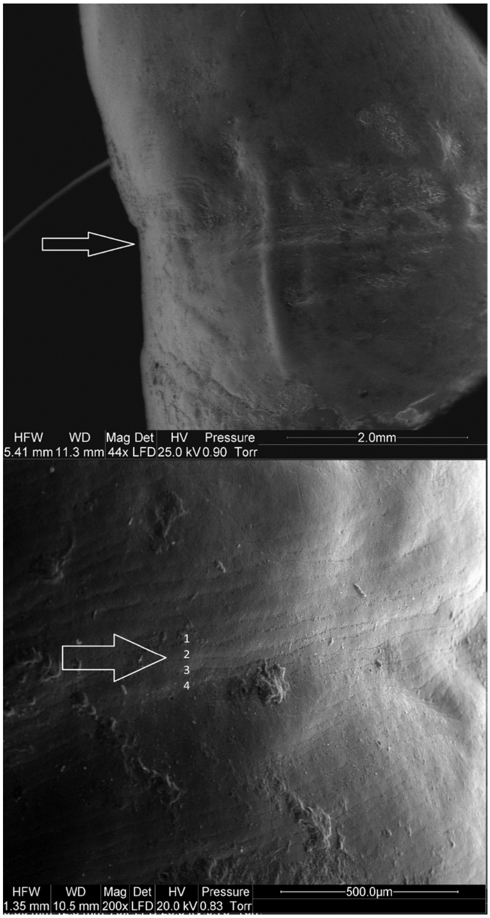

Fig. 4. SEM picture with diagnosed LEH

Discussion

The assessment of physiological stress on bone material is particularly interesting, but, due to the high fragmentation of archaeological material, it is not always possible to test these stress indicators. However, odontological material is usually well preserved in archaeological sites, so studies of such material are frequently used in anthropological research (e.g., Fitzgerald and Rose 2008, Temple 2010).

In the etiology of hypoplastic changes in tooth enamel, three main classes of factors have been listed: i) general (systemic), ii) local, and iii) genetic. General (systemic) enamel hypoplasia affects at least two or more teeth, which is caused by the general disorder of the body's functioning. This disorder may result from infectious diseases (viral or bacterial diseases and diseases causing high fever) (e.g., Nunn 2001, King et al. 2002), malnutrition, or general metabolic disorders (deficiencies in diet components – proteins; vitamins: A, C, D, K; elements: Ca, P, Mg, F) (e.g., Goodman et al. 1992, Pitsios and Zafiri 2012). In this respect, the changes classified as general (systemic) are most relevant in population studies (Hillson and Bond 1997, Hillson 2002, King et al. 2005, Ritzman et al. 2008). On the other hand, local enamel hypoplasia is characterized by a defect in only single teeth. Defects in a single tooth suggest a local etiological factor. The most common cause is mechanical injury to the tooth's germ (e.g., during extraction of the deciduous tooth) or the inflammatory process (e.g., pulpitis inflammation, which causes inflammation of the periapical tissue, which results in damage to the tooth's germ) (Suckling et al. 1987, Pindborg 1992, Anthonappa and King 2015). For this reason, this type of enamel hypoplasia cannot be the basis for assessing the health condition of an individual or their socio-economic status (King et al. 2005, Ritzman et al. 2008). In the case of the individual from Woźna Wieś, enamel hypoplasia was diagnosed only on one tooth (lower canine). It may mean that we have to do with the general or local type of enamel hypoplasia. Both classes of factors are possible, and it is difficult to say whether we have enamel defects resulting from a local etiological factor or effects such as malnutrition or disease. In studies of individuals from earlier chronological periods, this case would be omitted in the further research (e.g., Tomczyk 2016). However, in the described case, we have to make do with the extremely valuable, albeit fragmentary, material. This means that the enamel defect cannot be ignored in this study.

Comparison-obtained results of the enamel hypoplasia with other human remains from this region of Europe are problematic, due to the lack of dental material. The Mesolithic human remains from Groß Freienwalde, Brandenburg (Germany), where anthropological analyses identified one female with a child and two males with two children, did not contain enamel hypoplasia (Terberger et al. 2015). Also, skeletal remains from the Ypenburg population (the Lower Rhine Basin) did not have any dental pathology (Smits and van der Plicht 2009). Similar observations come from northern Poland. A human skeleton from Kamieńskie did not have any changes in dental enamel (Kozłowski 1998). A low level of enamel hypoplasia is visible on the dentitions of individuals from Vasilyevka 2 and 3 (Ukraine). Among 820 teeth, only 10 (1.2%) exhibited enamel hypoplasia (Lillie 1996). It can therefore be seen that enamel hypoplasia is not recorded on some dental material from the Mesolithic period from Central and Eastern Europe, or it is at a low level. It makes it possible to conclude that the examined individual from Woźna Wieś did not differ in terms of this physiological stress marker from other European specimens.

It was estimated that the LEH was formed from between 4.2 and 4.9 years of age. The late time of the defect formation excludes connections with the stress of weaning. Many studies suggest that the earliest enamel hypoplasia lines in bioarchaeological samples should be connected with the negative effects of weaning (e.g., Ungar et al. 2017, Berbesque and Hoover 2018). This is a dangerous period of childhood and very often has some impact on the distribution of dental lesions. Breast milk is a significant component of the diet and helps to develop the child's immunological system. As is well known, in many hunter–gatherer populations weaning took place between 3 and 4 years of age. The weaning period was shortened in agricultural and industrial populations (Marlowe 2005, Clayton et al. 2006, Berbesque and Hoover 2018). This means that the LEH of the Woźna Wieś individual could be explained by malnutrition or disorders caused by illness. Both interpretations seem likely.

As mentioned, it was possible to accurately calculate the number of perikymata. In the study case, the occlusal wall built three or four perikymata, from which it can be estimated that the physiological stress took place over a fairly short period of time (about 30–40 days). This could be explained by a short period of malnutrition or childhood disease causing disorders of enamel formation (especially with recurrent fevers, such as scarlet fever) (Al-Nazhan 1991, Anthonappa and King 2015, Merrett et al. 2016).

It is difficult to conclude on the basis of one individual about the entire Mesolithic population from the northern part of Poland. At this point, we should mention the "ostological paradox" and the relationship between the record of developmental stress and the dental defects found in sampled individuals (Wood et al. 1992, Wright and Yoder 2003). As we know, individuals vary dramatically in susceptibility to illness, which gives rise to an important question: Does a skeleton without evident lesions represent a healthy person or a weak individual who perished at the first exposure to a pathogen? Several scenarios might be proposed. One of them is that the individual from Woźna Wieś was healthy; hence, the LEH appeared in the late age of the individual. According to this proposition, we can hypothesize that lifestyles in Woźna Wieś during the Mesolithic period favored good adaptation of these populations to their environment. Human communities that relied on a hunter–gatherer economy had many different possibilities for obtaining food, and thus they minimized the threat of hunger (e.g., Berbesque et al. 2014). Moreover, the "nomadic" way of life resulted in a lower population density, which slowed the spread of pathogens to cause various diseases (e.g., Larsen 1995, Temple 2010). But we are not able to exclude another hypothesis that the environmental conditions were unfavorable. The idea that hunter–gatherer societies experience more frequent famine than societies with other modes of subsistence is pervasive in the bioarchaeological literature (e.g., Jankauskas 1994, Morales-Pérez et al. 2017). This means that in the described case, the individual from Woźna Wieś was "strong" enough to survive unfavorable conditions, and the trace of environmental stress was the formation of a single enamel hypoplastic line. Unfortunately, with only limited data from one individual, it is not possible to solve this problem.

Conclusion

Odontological research can provide much valuable information, facilitating improved knowledge of health conditions and an understanding of the direction of biological transformations within a given population over the centuries. In this context, modern techniques and devices that provide new possibilities for studying ancient materials are especially important. The analysis carried out on the Mesolithic individual from Woźna Wieś showed the presence of LEH on one tooth. The formation of this defect indicates a short disturbance in the functioning of the ameloblastic cells. This could have been caused by a short-term illness or the effect of brief food shortages.

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Authors' contributions

JT designed the research, interpreted the results and wrote the paper. AO conducted SEM analysis. The final version of the paper was prepared by JT and approved by AO.

Conflict of interest

The authors declare that there is no conflict of interests.

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