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ANTHROPOLOGY

DENTAL ENAMEL HYPOPLASIA. INVESTIGATIONS ON THE BONES EXHUMED FROM THE MEDIEVAL NECROPOLE OF LOZOVA (REPUBLIC OF MOLDOVA), XIVth–XVth CENTURIES

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Dental hypoplasia is a developmental anomaly based on perturbations of amelogenesis. Hypoplasia defects are part of the unspecific quantitative indicators for the state of health and / or nutritional state during the formation of the dental buds. It is a response of the human organism to physiological stress. The incidence of this dysplasia in a past population can indicate its biological frailty in its attempt to adapt to the environmental changes. The osteological material was excavated in the interval 2010–2011 by archaeologists from the Archaeology Centre in Chişinău, from the Medieval cemetery of Lozova (Străşeni County, Republic of Moldova), dated for the XIVth and XVth centuries. Fifty one skeletons from 50 inhumation graves have been excavated and analyzed so far. Only 40 individuals had most of their teeth present. The enamel hypoplasia is of linear transversal type, located on the labial surface of the dental crowns, in the median third. The canine is the most affected tooth, followed by the incisors. The incidence of dental enamel hypoplasia at population level (based on the data collected and on the number of graves excavates so far, which does not illustrate the entire population of the cemetery) is 7.5%. The incidence of dental caries is 23.53%, of *cribra orbitalia* – 11.75%, and of *cribra cranii externa* – 1.96%. The results obtained for a relatively small rural community illustrate a good adaptation to the stressing environmental factors. The possible malnutrition and illness episodes suffered during early childhood were recovered along the growth and development processes.

Key words: enamel hypoplasia, medieval necropolis, Lozova, XIVth–XVth centuries.

1. INTRODUCTION

Dental enamel hypoplasia is a developmental anomaly caused by perturbed amelogenesis [15]. Amelogenesis occurs in two stages, namely: secretion of matrix by ameloblasts, and its maturation [33]. The activity of ameloblasts may be inhibited by any environmental factor capable of inducing systemic physiological stress, which reduces the amount of secreted enamel. In the end of the secretory phase, a thinner enamel layer will be observed in the involved places. Consequently, enamel hypoplasia appears as a quantitative and not qualitative dental defect,

which is the case of – *e.g.* – enamel opacity. The presence of this anomaly indicates episodes of acute physiological stress suffered during formation of dental crowns [15, 38].

Enamel hypoplasia may be identified through the presence of ditches or either surface or deep small pits, horizontally or vertically arranged on the surface of the dental crown. One or several hypoplasic signs may occur on the same tooth, their severity ranging from microdefects, visibile only microscopally, up to perfectly visible defects. In very grave cases, enamel aplasia may appear [16, 38]. Usually, the hypoplasic defects appear bilaterally (left and right), both on the lingual surface of the crown, preponderantly on the labial / facial one; in certain situations, they circumscribe the tooth [17]. Their localization is more frequent in the median third of the crown, followed by the cervical and incisal / occlusal thirds [12, 15]. The sizes (depth and width) of the hypoplasic defects are directly correlated with the severity, duration and intensity of the stressing agent [1, 39].

Enamel hypoplasia affects only the teeth whose crowns are formed during stress periods, the defects appearing only in the enamel portion formed in the time interval in which the stress factor had been active [35]. Mention should be made of the fact that, for temporary dentition, amelogenesis takes place only in the intrauterine period while, for the permanent dentition, from birth up to the age of 6–7 years, or up to 13 years in the case of the wisdom tooth [34].

The teeth more vulnerable to hypoplasia are those whose enamel is developed between the 2–3 year age interval. The incisors and the canine teeth are considered as most sensible to the physiological stress, which makes them the best ”tools” for illustrating enamel hypoplasia [2, 14, 34].

The factors responsible for dental enamel hypoplasia may be grouped into three main categories: traumatisms, malnutrition / subnutrition and infectious diseases. The general idea is that two or several environmental factors, interacting between/ among them are necessary for producing enamel lesions. An increased density of the population and, implicitly populational sedentarism, alongwith the radical modification of the alimentary or cultural habits may also induce hypoplasic defects [4, 8, 14]. Therefore, the main etiology involves the physiological stress which, associated with malnutrition and maladies, perturbs enamel development. Worth mentioning is also the fact that dental enamel hypoplasia cannot be precisely attribuited to a certain disease or to some specific nutrition deficiencies, so that it should be viewed only as an indirect, non-specific indicator of health condition [15, 34].

Some of the investigations devoted to the incidence of dental displasia in extincted populations evidenced that the age at which the hypoplasic defects are forming usually coincides with the weaning moment, when the child is more exposed to bacterial and parasitary infections which, in their turn, inhibit digestion of nutritive substances; more than that, if subnutrition accompanies this moment, this triple causality will certainly favourize the occurrence of dental defects [5, 6, 7, 13, 21, 43].

As to the association with other skeletal anomalies, hypoplasia of dental enamel frequently occurs in the vicinity of the Harris lines and, sometimes, near the porotic lesions, such as *cribra orbitalia* or hyperostosis [1, 6, 13 Another association is with dental caries, to which the hypoplasic teeth are more susceptible than the normal ones. Positive correlations have been also established with the low-size adult stature, here involved being also socio-economic factors [6, 11].

Regarding the incidence of dental hypoplasia registered by bioarchaeologists along time, in populations from quite different parts of the world, it generally varies between 0 and 60% [9, 25, 32]. In spite of the rapid medical progress of today, in poor people, enamel hypoplasia is as common nowadays as in the past – prehistory and history [19, 27]. At present, the incidence of enamel hypoplasia is higher in children from the developing countries, comparatively with those from the developed ones [3, 10, 11, 23, 28], a situation evidencing once more the essential importance of the socio-economic condition in the manifestation of such defect.

As, once formed, the traces are irreparable, becoming permanent characteristics of the crown, one may deduce that dental hypoplasia "memorizes" the episodes of physiological stress experienced during childhood. According to this characteristic, enamel hypoplasia belongs to the category of permanent indices of health condition in some population (even if indirectly and non-specifically), so that it may offer a glimpse on it. However, in some situations, the hypoplasic lines disappear, but only when the crown is eliminated through mechanical dental wear or when carious processes occur.

2. MATERIALS AND METHOD

The osteological material utilized in the present study had been exhumed in 2010–2011 by the arcahaeologists of the Center of Archaeology Chişinău from the medieval necropole of Lozova (Republic of Moldova). The cemetery belonged to a local Christian rural community. According to the data offered by specialists on the basis of the funeral inventory (no coins being available), the cemetery seems to have been utilized between the end of the XIVth century and the XVth century [41]. The skeletal series exhumed up to now, analyzed in the present study, includes 51 skeletons digged out from 50 inhumation tombs: 22 males, 13 females and 16 children. Out of these 51 skeletons, a ratio of 78.4% had almost all teeth: 18/22 men, 10/13 women and 12/16 children.

Mention should be made of the fact that the investigation involved only macroscopic observations. The teeth (either those in the sockets, or those lost *post mortem* and recovered from the grave) were cleaned, the earth and the calculus being removed, then examined in proper light, sometimes with a monocular 5 × magnifying glass.

Enamel hypoplasia was analyzed according to the DDE Index, even if other registration methodologies have been also considered. The severity degree was established according to the method proposed by King, Hillson and Humphrey [22]. Recording of the hypoplasia type considered four main categories, namely: pits, horizontal ditches, vertical ditches and areas wholly devoid of enamel [DDE Index]. To determine whether the identified dental displasia is hereditary or acquired, the whole dental assembly of each subject should be analyzed [12, 15]. Localization of enamel hypoplasia was observed on three anatomic dental surfaces: facial, lingual and occlusal. On the crown of each tooth, it was established whether the hypoplasic defect is singular or multiple, well-delimited or diffuse [DDE Index]. The degree of dental wear was stated according to the method proposed by Smith and Knight [36].

Determination of the age at which the hypoplasic defect first appeared was based on the method proposed by Goodman, Armelagos and Rose [14]. For each hypoplasic tooth, the digital caliper (with an error around 0.01 mm) was used for measuring the following parameters: distance between the cement-enamel junction and the center of the hypoplasic defect; distance between the cement-enamel junction and the occlusal margin. The obtained values have been subsequently introduced in the regression equation:

$$\text{Age at formation of defect} = [\text{Age at crown completion} - \left(\frac{\text{years of formation}}{\text{crown height}}\right) \times \text{defect height from CEJ}]$$

3. RESULTS AND DISCUSSION

Out of the 40 subjects in which most of the teeth had been tested, only 3 were identified as “carriers” of dental enamel hypoplasia.

Case 1. Grave no. 14, male, age at decease around 30–35 years. Both dental arches are present. Reduced dental wear, of atrition type, degree 1 towards 2. No dental caries. The brown-coloured calculus occurs as in a thin layer in the jugal portion and in as a somehow thicker layer, yet easily detachable, in the masticatory areas. In this patient, enamel hypoplasia is of linear horizontal type. At the level of the maxilla (Fig. 1), the affected teeth are the central incisors and the canine teeth while, at mandibular level – the central and lateral incisors, the canine teeth, premolars I and molars I (Fig. 2), the remaining teeth being apparently normal. The severity of hypoplasia is moderate, the dentin layer being not affected. Defects are more visible on the upper central incisors and upper canine teeth. Molar I evidence only one, well-delimited hypoplasic line, which surrounds the tooth. The other affected teeth (incisors, canine teeth and premolars I) show multiple and diffuse hypoplasic lines, localized exclusively on the labial surface. As to the age interval within which the hypoplasic lines had been formed, it was calculated as being around 2 and 3 years.

The 30–35 year-old man here analyzed shows *cribra cranii externa* – an indicator used for evaluating the health condition and nutritional status of the extincted populations [30]. Other anomalies identified on this skeleton, not related to enamel hypoplasia are: at cranial level – four ossicles on the lambdoid suture, bilateral *torus auricularis* and double bilateral zygomatico-facial foramen; at postcranial level – complete lumbarization of the last sacral vertebra and spondylolysis at the level of the last lumbar vertebra.

Fig. 1. Grave no. 14, male, 30–35 year-old, Maxilla.

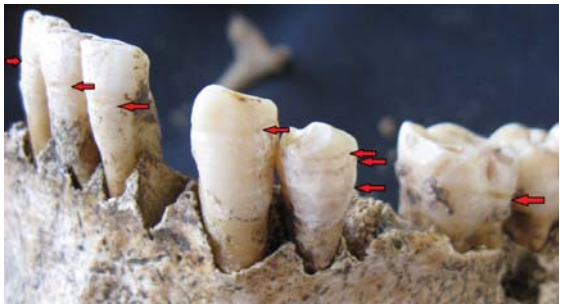

Fig. 2. Grave no. 14, male, 30–35 year-old, Mandible.

Case 2. Grave no. 29, female, decease age around 19–20 years. Low dental arch almost complete, while the upper maxillary has only 15 isolated teeth. Dental wear of atrition type, degree 1 towards 2. Three carious processes: a 1–2 degree caries on the inferior left molar II; a 2 degree caries on the left lower molar I; a 5 degree caries (radicular rest) on the right lower molar I (Fig. 4). The whitish calculus was moderately deposited on the jugal teeth, and also as a thick, highly-adherent layer on the enamel of the masticatory teeth. Enamel hypoplasia is also of linear horizontal type. The central and lateral incisors, the canine teeth and premolars I are affected (Figs. 3 and 4). The remaining teeth are apparently normal. The severity degree is somewhat lower, comparatively with the above-described one. Linear defects are superficial, not having reached the dentin layer, appearing slightly more pronounced in incisors and canine teeth. The affected teeth evidence multiple, diffuse hypoplasic lines, localized on the labial surface. The age interval over which the hypoplasic lines had appeared in this subject ranges between 1.5 and 3 years.

Other anomalies identified on this skeleton, not related to enamel hypoplasia, are: at postcranial level – Schmorl's nodes (intervertebral hernia) on a thoracal vertebra and on two lumbar vertebras and incomplete sacro-coccigian junction.

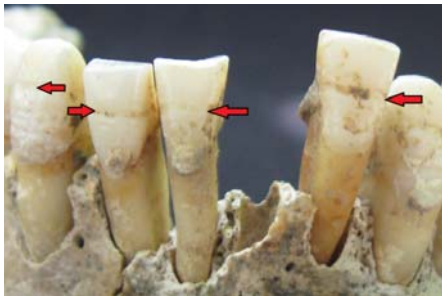

Fig. 3. Grave no. 29, female, 18–20 year-old, mandible.

Fig. 4. Grave no. 29, female, 18–20 year-old, Mandible.

Case 3. Grave no. 3, individual of undeterminable sex, with a decease age around 7–8 years. Fragmented maxilla, represented only by the right hemiarch, also incomplete, the following teeth being present in the alveoles: temporary canine tooth, temporary molar I, temporary molar II and permanent molar I. The mandible is complete, with almost all teeth present in the alveoles. The left mandibular hemiarch contains: permanent molar I, temporary molar II, temporary molar I, temporary canine tooth (lost *post mortem*), temporary incisor II and temporary incisor I. The right mandibular hemiarch contains: the temporary incisior I, temporary incisor II, temporary canine tooth, temporary molar I, temporary molar II and permanent molar I. Mention should be made of the fact that the permanent molars II appear as non-errupted, non-calcified buds; the inferior permanent central incisors appear in eruption, evidencing mineralized crowns and 1/3 of the roots already formed; the left inferior permanent canine tooth, non-errupted, shows mineralized crown and 1/5 of the root already formed.

Viewed as a whole, the wear degree of temporary dentition is very low. However, if considering especially the lower central incisors (Fig. 7), then the "wear" appears wholly different, having a similar aspect with that of Hutchinson incisors, even if here under discussion is temporary dentition. The islands of dentin are obvious, the occlusal margins of the two incisors being deformed, with a crescent aspect. Unfortunately, the upper central incisors are absent. A peculiar aspect should be mentioned for the final molars I (Figs. 5 and 6), namely an irregular occlusal surface, with a mulberry aspect ("*mulberry molars*"), wrinkled enamel and hardly visible malformated cuspides.

The etiology of Hutchinson's teeth and of the "mulberry molars" involves perturbations of enamel calcification during amenoblastic morpho-differentiation (the intrauterine period), the cause being the presence of spirochaeta *Treponema pallidum* (the pathogenic agent of syphilis) in the organism of the pregnant woman. The newly-born child of a mother suffering from syphilis may display obvious signs of the malady or it may be apparently healthy, the signs of the infection appearing

only later on, in the first year of life or even later, up to the age of 10–12 years. In children suffering from congenital lues, generally, only the permanent incisors and permanent molar I are affected, as they are the only permanent teeth of this evolution stage. Normally, temporary teeth are not affected [18, 20], which is the case of the child skeleton here under analysis, which explains the reserve of the authors on the "diagnosis" of congenital syphilis.

Fig. 5. Grave no. 3, indeterminate gender, 7–8 year-old, maxilla.

Fig. 6. Grave no. 3, indeterminate gender, 7–8 year-old, mandible.

As to the final molars with a mulberry aspect (Figs. 5 and 6), a recent study defines this type of defect as "*CEH – cuspal enamel hypoplasia*", a new form of rarely occurring hypoplasia [29], the possible causes, more frequently invoked than the congenital lues, being: the insufficient contribution of vitamin D in the intrauterine period [24], hypoxia at birth [40], neonatal tetany [31], severe rachitism in the first year of life or a prolongued suckling period, inducing vitamin D deficiency [24, 29, 42].

Unfortunately, the skeleton of this child is extremely incomplete. The postcranial part is represented only by the coxal bones and by five costal fragments, which can hardly provide data to confirm or to exclude congenital syphilis. Hardly useful are also the (frontal, parietal and occipital) bones of the skull, which do not evidence symptoms specific to lues (such as, for example, the pronounced frontal bossing). Consequently, with the necessary reserves, imposed by the above-mentioned shortcomings, the authors believe that the 7–8 year-old child from tomb no. 3 might have suffered from a peculiar, very rare form of dental hypoplasia, sometimes associated with congenital syphilis, at other times with rachitism, hypoxia or neonatal tetany and, why not, with delayed ablactation.

Apart from the peculiar aspect of the temporary lower incisors (Fig. 7) and of the permanent molars I (Figs. 5 and 6), the dentition of this child has another unusual characteristic. On the crown of the permanent left upper canine tooth (non-errupted, forcedly extracted by us from the socket), a horizontal, superficial, diffuse hypoplasic line was identified, localized on the labial surface (Fig. 8), formed, according to calculations, in the 2.5–3 year age interval. Even if assuming

that this child had been affected by *Treponema pallidum* through his mother's placenta or that he had suffered from severe rachitis, his organism would have been subjected, anyway, to an acute physiological stress over the 2.5–3 year age interval.

None of the analyzed teeth shows caries. A thin calculus layer is present on the temporary molars, at the cement-enamel junction. At cranial level, mention should be made, bilaterally, of *cribra orbitalia* – a porosity frequently discussed in literature as associated with enamel hypoplasia. Other anomalies identified at cranial level, yet not related with enamel hypoplasia, are: the *Inca* ossicle (42 mm/25 mm), seven ossicles on the lambdoid suture (6 on the left side and 1 on the right) and a unilateral parietal (right) foramen.

Fig. 7. Grave no. 3, indeterminate gender, 7–8 year-old, maxilla + mandible.

Fig. 8. Grave no. 3, indeterminate gender, 7–8 year-old, permanent left mandibular canine, unerupted.

Populational analysis. At populational level, hypoplasia of dental enamel records a general incidence of 7.5%. Separate analysis on sexes gives the following results: 5.55% of the men and 10% of the women had suffered at least one episode of physiological stress during childhood. In all cases under investigation, enamel hypoplasia was manifested only on few dental units, which supports the presence of some acquired and not hereditary displasia forms. The types of hypoplasia identified in the present study are moderately severe, of linear transversal type, most frequently localized on the labial surface of the dental crowns, in their median third. Most commonly affected is the canine tooth, followed, in decreasing order of frequency, by the central incisor, lateral incisor, premolar I and molar I. Generally, the affected teeth show one well-delimited hypoplasic line and several diffuse lines, which suggests that the here analyzed individuals, respectively the population to which they belong, have/has frequently suffered physiological disorders during childhood [14]. The degree of severity is broadly moderate. The degree of atrition is low.

As to the association with other anomalies or pathologies manifested at dental, as well as at cranial levels, quite interesting results have been recorded. Association with carious processes gives a dental caries incidence, at the level of the whole population under study, of 23.53% (27.27% for men and 46.15% for women, respectively). In the cases illustrating exclusively enamel hypoplasia, dental caries are associated with it in only one case – namely, in the 19–20 year-old woman from grave no. 29. The association between dental enamel hypoplasia and cranial porosities has been also analyzed, as both of them derive from childhood, representing episodes of acute stress suffered during growth, and reflecting modifications of the hard tissues which had not been remodelled, any more [26, 37]. In the population exhumed up to now from the medieval necropole of Lozova, the incidence of *cribra orbitalia* is of 11.76%, while that of external cranial porosity is of 1.96%. Mention should be again made of the fact that the incidence of enamel hypoplasia in the here analyzed segment of population is of 7.5%, with a sexual dimorphism in favour of women (5.55% for men and 10% for women). When considering exclusively the 3 cases illustrating dental enamel hypoplasia, the following results were obtained: *cribra cranii externa* is present only on the skeleton of the 30–35 year-old man from grave no. 14, whereas *cribra orbitalia* – on that of the 7–8 year-old child from grave no. 3. The skeleton belonging to the 19–20 year-old woman from grave no. 29 evidences no porosity at cranial level.

4. CONCLUSIONS

Especially in the rural areas, the medieval period has been frequently associated with malnutrition and a higher incidence of infectious diseases. It is exactly this aspect that challenged the authors to analyze the hypoplasia of dental enamel, for establishing whether the small segment of the rural population exhumed from the necropole of Lozova (XIV^{th}–XV^{th} centuries) confirms the general observations on the health condition of the medieval communities.

Hypoplasia of dental enamel was identified in 3 of the 40 observable individuals: in the 30–35 year-old man from grave no. 14; in the 19–20 year-old woman from grave no. 29 and in the 7–8 year-old child from grave no. 3, which gives an incidence of this defect, at populational level, of 7.5%. In each case considered for analysis, enamel hypoplasia affected only a few dental structures (acquired dental displasia). Hypoplasic defects are of horizontal linear type, being usually localized on the labial surface, in the median third of the crown. In decreasing order of frequency, the affected teeth are: the canine tooth, the central incisor, the lateral incisor, premolar I and molar I. On almost all dental crowns affected with hypoplasia, a well-delimited defect and several diffuse lines may be observed, which susgests that, at child ages, the analyzed population had frequently suffered from physiological, even if low-intensity disorders. The extent of severity of hypoplasia is a moderate one. The age interval at which the acute physiological

stress was manifested ranges, generally, between 1.5 and 3 years. In the man exhumed from grave no. 14, the hypoplasic lines had been formed between 2 and 3 years, in the woman from grave no. 29 – between 1.5 and 3 years, and in the child from grave no. 3 – between 2.5 and 3 years.

The child exhumed from grave no. 3 illustrates a special situation, leading to a different conclusion. The skeleton of this child, with the age at decease around 7–8 years, displays some elements (temporary incisors with Hutchinson aspect and molars with mulberry aspect) permitting the following assumptions: 1) the presence of congenital syphilis; 2) an episode of hypoxia and/or neonatal tetany; 3) lack of a sufficient amount of vitamin D, causing to severe rachitis in his first year of life. A final "diagnosis" cannot be established, as the skeleton is highly fragmented and incomplete. However, a rare form of dental hypoplasia, known as "*CEH – cuspal enamel hypoplasia*", has been definitely ascertained, accompanied by linear hypoplasia of dental enamel on the final canine tooth (still not erupted up to the moment of death), induced by an episode of physiological stress produced in the 2.5–3 year age interval. This confirms the hypotheses that enamel hypoplasia may be also indicative of infantile morbidity in the extincted populations.

The incidence of *cribra orbitalia* in the population exhumed from the medieval necropole of Lozova is of 11.76%, while the incidence of *cribra cranii externa* is of 1.96%. Out of the three cases with hypoplasia of dental enamel, cranial porosity appears only in two of them, namely: *cribra cranii externa* – on the skeleton of the 30–35 year-old man from grave no. 14, and *cribra orbitalia* – on the skeleton of the 7–8 year-old child from grave no. 3. Enamel hypoplasia is associated with dental caries in only one case of the three here considered, namely in the 19–20 year-old woman from grave no. 29.

Once known that, actually, the hypoplasic lines represent the response of the human organism to the action of a non-specific physiological stress, they actually illustrate the biological frialty of a population obliged to get adapted to the environmental modifications it witnessed. The results here obtained on a small-sized (51 individuals) rural medieval community demonstrate a relatively good adaptation of the population of Lozova to the stressing environmental factors, the possible episodes of malnutrition or diseases suffered during early childhood being subsequently recovered.

Authors contributions: Robert Daniel Simalcsik (first author) – 50%; Angela Simalcsik (second author) – 30%; Vasilica-Monica Groza (second author) – 20%.

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