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Review

Neonatal line width in deciduous incisors from Neolithic, mediaeval and modern skeletal samples from north-central Poland

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ABSTRACT

The neonatal line is usually the first accentuated incremental line visible on the enamel. The prenatal environment significantly contributes to the width of the neonatal line, influencing the pace of reaching post-delivery homeostasis by the newborn's organism. Studies of the enamel of the earliest developing deciduous teeth can provide an insight into the prenatal development and the perinatal conditions of children of past human populations, thus being an additional source contributing to consideration of the influence of prenatal and perinatal factors modifying growth processes.

The aim of this study was to examine whether the neonatal line, reflecting the conditions of the prenatal and perinatal environment, differed between the Neolithic, the mediaeval and the modern populations from the Kujawy region in north-central Poland.

The material consisted of longitudinally ground sections of 57 human deciduous incisors obtained from children aged 1.0–7.5 years representing three archaeological series from Brześć Kujawski site.

All teeth were sectioned in the labio-linqual plane using a diamond blade (Buechler IsoMet 1000). Final specimens were observed with the microscope Delta Optical Evolution 300 at 10× and 40× magnifications. For each tooth, linear measurements of the neonatal line width were performed on its labial surface at the three levels from the cemento–enamel junction.

No significant difference was found in the mean neonatal line width depending on the tooth type and archaeological site, although the thickest neonatal line characterised children from the Neolithic series.

In all analysed series, the neonatal line width was diversified depending on the child's age at death. The value of Spearman's rank correlation coefficient calculated for the correlation between the child's age at death and the neonatal line width was statistically significant. A clear increase in the width of the neonatal line was thus observed along with a decrease in the child's age at death.

Contents

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1. Introduction

The enamel of deciduous teeth, once formed, does not undergo any remodelling, and its gradual process of formation beginning in the second trimester of pregnancy (Sunderland et al., 1987; Mahoney, 2012) allows the preservation of traces of metabolic disturbances during the prenatal period (FitzGerald and Saunders, 2005). Although the process of enamel formation is strongly genetically determined, exogenous factors may cause the appearance of macroscopically visible enamel hypoplasia and microscopically observable accentuated Retzius striae, grooves or lines or Wilson bands. Larsen (1987) noted that "any specific condition that will affect the normal growth and metabolism of the body cells will likewise affect the growing cells of the dentition thus giving a retrospective picture of morbidity".

The neonatal line is usually the first accentuated incremental line visible on the enamel. It separates the enamel formed prenatally from the enamel formed postnatally, which are characterised by a different quality (Eli et al., 1989; Kodaka et al., 1996; Humphrey et al., 2007; Canturk et al., 2014). This accentuated incremental layer of enamel deposited after birth, corresponding to a stria of Retzius (Skinner, 1992; Hillson, 2014), extends from the enamel–dentin junction in the cervical part of the tooth through the whole thickness of the enamel. The average width of the neonatal line observed by optical or scanning microscopy, for children born naturally equals about 12 μm (Eli et al., 1989; Sabel et al., 2008). The neonatal line is observed in all teeth undergoing the mineralisation process in the prenatal period (Eli et al., 1989; Sabel et al., 2008; Antoine et al., 2009)—in all deciduous teeth and in about 10% of permanent first molars (Skinner and Dupras, 1993).

The neonatal line in primary tooth enamel corresponds to the event of birth and is associated with perinatal stress (Gustafson and Gustafson, 1967 after Molnar and Ward, 1975), understood as the change in conditions of the living environment resulting from the passing from the intrauterine to the external environment and as a result of the change in the quality and the manner of nutrition (Szpringer-Nodzak, 2005). The neonatal line is also associated with the occurrence of neonatal hypocalcaemia (Norén, 1983). All children experience a decrease in the calcium level in the blood within 24 h after birth, which is connected with the interruption of placental transport (Carpenter, 1999). The decrease in the availability of calcium ions can influence the activity of ameloblasts, a consequence of which may be the neonatal line (Norén, 1984).

When analyzing neonatal line width, one should bear in mind that "the apparent width of this fuzzy dark band seen in the microscope does not represent the actual width of a structure in the section, but presumably in some way represents the degree of disruption" (Hillson, 2014, p. 122). The appearance of the neonatal line results from disturbances of the ameloblasts while secreting enamel matrix (reflecting the immediate effect of actual birth stress) and reflects processes that might have a direct relation to the birth process but could also arise from the ongoing enamel maturation during the further life of an individual. According to Witzel et al. (2008) the factors that influence reaction pattern of secretory ameloblasts to stress events can be reconstructed from microscopic analysis of mature enamel. Among these factors, there are not only "the impact duration and intensity (birth stress) but also ameloblast susceptibility resulting from the age and the stage of the cell within and individual activity cycle" (Witzel et al., 2008, p. 412). Witzel et al. (2008) also reported a significant correlation between the occurrence of a pronounced accentuated line in thin enamel sections and plane-form hypoplasia on the surface of tooth crowns.

The prenatal environment significantly contributes to the width of the neonatal line, influencing the pace of reaching the post-delivery homeostasis by the newborn organism. Research into the variability of the neonatal line indicates that neonatal line width is largely influenced by prenatal disturbances and prenatal factors related to gestational development (Kurek et al., 2014) and gestational length (Zanolli et al., 2011), while not being correlated with measured values of neonatal blood ionised calcium (Ranggård, 1994) or hypocalcaemia in the first days of the infant's postpartum life (Ranggård et al., 1995). A wider neonatal line is found in preterm children and in children with a lower birth weight (Szpringer-Nodzak, 1984; Zanolli et al., 2011) as well as in children of diabetic mothers (Norén, 1984).

According to the literature, prenatal and early childhood development have a significant impact on an organism's parameters in later life, later morbidity and mortality (Barker, 1995; Humphrey and King, 2000; Cameron and Demerath, 2002; Crump et al., 2011; Entringer et al., 2011). In present-day human populations the most frequent causes of infant mortality are infections, premature births, complications during delivery, perinatal asphyxia and birth injuries (NICHD, 2013). There have been an increasing number of studies examining tooth enamel as potential evidence for prenatal and early childhood stress in archaeological skeletal samples (Alexandersen et al., 1998; FitzGerald and Saunders, 2005; Macchiarelli et al., 2006; FitzGerald et al., 2006; Antoine et al., 2009; Schwartz et al., 2010). According to studies analysing the number of accentuated lines observed in pre- and postnatally formed enamel, children with a greater number of disorders are characterised by earlier (Rose et al., 1978; Rudney, 1983) or later (FitzGerald et al., 2006) age at death. This result could be associated with the so-called osteological paradox (Wood et al., 1992). Children with and without disturbances could be characterised by different frailty (FitzGerald et al., 2006).

Although neonatal line width seem to be associated with prenatal development and gestational length (Szpringer-Nodzak, 1984; Zanolli et al., 2011; Kurek et al., 2014) there is lack of papers analyzing a relationship between neonatal line width and child's age et death in different archaeological samples.

Human populations inhabiting north-central Poland during the Neolithic period, the middle ages and the modern times, while developing in a different environment, differ significantly in biological respects. These differences are observed among others in the mean age of occurrence and duration of enamel hypoplasia, in the observed frequency of porotic hypertrophic lesions of the skull bones and in the frequency of occurrence of Harris lines in the long bones (Lorkiewicz, 2012). It can thus be expected that differences in the developmental environment, including differences in the prenatal, perinatal and postnatal environment during growth will be visible in the differentiated width of the first accentuated incremental line observed in deciduous teeth.

The purpose of this study was to examine whether the neonatal line, reflecting the conditions of the prenatal and early postnatal environment, differed between the Neolithic, the mediaeval and the modern populations from the Kujawy region in north-central Poland and whether the neonatal line width in these samples is associated with the age of child's death.

2. Materials and methods

2.1. Sample

The dental material consisted of 57 caries-free deciduous maxillary central incisors and mandibular lateral incisors, characterised by insignificant wear of the crown, not exceeding degree 2 (mild tooth wear meant clearly discernible wear in the enamel only, with the occlusal/incisal morphology slightly altered), in the four-degree scale proposed by Warren et al. (2012).

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