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Detection of Enamel Hypoplasia Using Artificial Intelligence Technologies and Creation of a Personalized Treatment System

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Abstract Analysis of various scientific sources shows that dental hard tissue diseases are in the first place in terms of prevalence. They pose a challenge to all doctors with their multifaceted impact on the body. Enamel hypoplasia is widespread not only in the countries of Europe and America, but also in all countries of the world.

Keywords Hypoplasia, Enamel, Erosive hypoplasia, Sulcular hypoplasia, Mixed hypoplasia, Oral cavity, Encephalopathy, Nephropathy

1. Introduction

Amelogenesis occurs in three stages [4,16]. During the first stage, the stage of secretion and primary enamel mineralization, enameloblasts secrete the organic base of the enamel, which immediately undergoes primary mineralization with the help of amelogenin proteins. During the second stage, secondary enamel mineralization, with the help of enamelin proteins, additional mineral components are incorporated into its composition. The third stage, the final maturation, or tertiary stage, occurs after tooth eruption and is characterized by the completion of enamel mineralization, mainly due to the influx of ions from saliva [12,14].

Enameloblasts, proteins that transport hydroxyapatite crystals to form enamel prisms, are highly sensitive to deviations from the normal course of amelogenesis. Even minor environmental, systemic, toxic, and other influences can manifest as morphologically noticeable changes in the composition and quantity of enamel tissue. These can include trauma, nutritional deficiencies, general diseases, environmental factors (high fluoride levels in water), and many other causes. If the influence occurs during the period of enamel secretion, the amount of enamel formed in a given area decreases and is clinically manifested by some kind of lesion [8]. Enamel hypoplasia is a quantitative and qualitative underdevelopment of enamel due to a disruption of metabolic processes in developing teeth [5].

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It occurs in temporary and permanent teeth. A distinction is made between systemic, local, or focal hypoplasia. Systemic hypoplasia is characterized by a disruption of the enamel structure of all teeth or only that group of teeth that is formed in single stripes located parallel to the cutting edge; this indicates how many times such a metabolic disorder has occurred [6,8]. Yu.A. Fedorov et al. (1997) proposed classifying systemic hypoplasia into spotted, erosive, sulcular, and mixed forms. The most common is the spotted form (47.1%). The erosive form is somewhat less common (29.4%). The mixed form of enamel hypoplasia was detected in 18.8% of cases. The rarest is the sulcular form (4.7%). The main consequence of enamel hypoplasia is the development of caries. Considering that microbes do not require much effort to destroy diseased enamel, caries nests appear on several teeth at once and become deep within a short time [1,2,8]. We present clinical observations.

The aim of the study was to develop an innovative dental diagnostic system based on artificial intelligence technologies and a treatment system for the early detection of enamel hypoplasia in children, enabling individualized treatment.

The most characteristic sign of hypoplasia is the symmetry of the lesion, i.e., the location of spots, erosions, or grooves on the teeth of the right and left halves of the jaw. A sharp boundary between the spot and the rest of the tooth is also characteristic. The location of the changes in the enamel can be used to estimate the age at which the metabolic disorder in the dental follicle occurred. The surface of the defect smooth, shiny, or dull also depends on the period of enamel formation during which its mineralization was disrupted. The width of the affected enamel area indicates the duration of the metabolic disorder, and the number of hypoplastic spots located at the same level indicates the duration of the metabolic disorder.

Upon probing, the enamel is smooth and dense, with the exception of tooth 2.2, where the walls and floor of the defect are rough and uneven. The Green-Vermilion Hygiene Index was 2.3, indicating poor hygiene. A diagnosis of systemic hypoplasia, macular form, complicated by the development of caries in tooth 2.2 was made. The patient underwent professional oral hygiene, and personal hygiene products were selected. The hard tissue defect in tooth 2.2 was closed with glass ionomer hybrid cement after preparation. The patient is invited for a follow-up examination in three months. Patient K., 13, presented with complaints of pain from chemical and thermal irritants in tooth 4.3. Upon examination, symmetrically located spots are detected on the vestibular surfaces of all teeth in the upper and lower jaws. Upon probing, the enamel is smooth and dense. Tooth 2.2 was previously restored with a composite filling material. A carious cavity is detected in the cervical area of tooth 4.3. The diagnosis is systemic hypoplasia, a spotted form, complicated by the development of a carious process in tooth 4.3. It should be noted that the treatment of hypoplasia is quite complex. Defects in permanent teeth can only be corrected using microprosthetic technology [5]. Enamel hypoplasia is a problem that is little discussed, but which is becoming increasingly common. And if caries and periodontitis are today the “leaders” in prevalence in the children’s oral cavity, then hypoplasia is the “leader” in the number of adverse consequences, difficulty of diagnosis and treatment [2,7].

Depending on the degree of activity, cervical caries is divided into three types:

Compensated. Tooth decay progresses slowly, with isolated enamel lesions detected upon examination. It is necessary to visit a dentist every three months and regularly undergo enamel remineralization (strengthening) both at home and at the dentist's office [5].

Subcompensated. Enamel lesions develop over several months. Regular dental hygiene and enamel strengthening with fluoride-containing compounds are also necessary. A single restoration with a composite material may be possible, depending on the depth of the lesion [4].

Decompensated. Severe, the carious process develops rapidly and spreads to adjacent teeth, is accompanied by acute pain, and requires immediate treatment. Most often, this type of lesion is treated under general anesthesia, and the damaged teeth are restored with crowns [2].

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2. Research Methods

The study utilized anamnestic data, data from a program developed using artificial intelligence technologies, a questionnaire, laboratory tests, and statistical methods (Student's and Pearson's t-tests).

There are three types of pathology: systemic, focal, and local.

Systemic enamel hypoplasia in children manifests as extensive damage to a large area of the dentition. It is always a congenital condition and has several forms, including: macular – accompanied by the formation of rounded, light spots on the enamel without structural damage; erosive – characterized by the appearance of depressions on the tooth surface; sulcular – manifests as wavy grooves on the enamel; mixed – combines two or more forms of hypoplasia simultaneously [10].

Local enamel hypoplasia is localized and affects no more than 2-3 primary or permanent teeth. This is manifested by the appearance of round spots, pits, and grooves of various shapes. It is acquired and develops due to infectious or traumatic damage to the oral cavity [1,9].

Focal enamel hypoplasia in children is characterized by the fact that it can simultaneously affect both primary and permanent teeth of different ages, with structural changes in all layers of enamel developing on several units at once [3,5].

The disease may be associated with intrauterine developmental disorders, exposure to various pathogens, malnutrition, poor ecology, and general illnesses of the mother or child [2].

During pregnancy: poor nutrition and alcohol consumption by the mother during pregnancy; endocrine pathologies; calcium metabolism disorders; infections during pregnancy: toxoplasmosis, rubella, acute respiratory viral infections, influenza; severe pathologies: encephalopathy, nephropathy, and others; Rhesus incompatibility between mother and child. During and after childbirth: prematurity; asphyxia or trauma during birth; hemolytic disease of the newborn; perinatal infection; blood transfusion in the first days of life [8].

In the first years of life: poor nutrition; artificial feeding; chronic renal failure; severe infections; allergies; gastrointestinal pathologies; congenital diseases (hypothyroidism, metabolic disorders, cardiac and vascular pathologies); iron deficiency anemia. If the causes of the disease lie in prenatal development, then the manifestation of symptoms is possible as early as the first months after the eruption of primary teeth. Before the age of 2, underdevelopment of enamel can be noticed in the cervical area (closer to the gum) of the central and lateral incisors, as well as on the chewing surface of the first molars. By the age of 4, signs of the disease become noticeable on the canines and second molars [4].

If the onset of the disease occurred in the first years of life, then the first symptoms most often appear after 6-7 years of age during the eruption of permanent teeth. The problem can be noticed by whitish spots on the teeth. Moreover, most often, the tooth already erupts with these spots. In some cases, instead of spots, longitudinal lines (from the gum to the tip of the tooth) or transverse waves (from the left edge of the tooth to the right) may be present. These defects may decrease in size over time, which is associated with the ongoing process of enamel formation [3].

In more severe cases, areas with characteristic depressions resembling erosion are visible on the surface. The enamel in these areas is thin and sometimes absent altogether. The tooth surface is rough to the touch. The most severe manifestation of this pathology is the complete absence of enamel (aplasia). In this case, teeth are extremely sensitive to hot, cold, and acidic substances. Hard tissues are brittle and prone to decay [1,5].

Since the enamel is underdeveloped in problem areas, it does not perform a protective function. Caries-causing bacteria easily attack it, penetrating through it into the dentin. Therefore, young patients experience rapid development of caries. This manifests as spots on the enamel at first yellowish, then darker. Areas severely affected by caries have a brownish tint and the presence of cavities.

Depending on the location of the problem, a distinction is made between systemic enamel hypoplasia, which affects all teeth and most often manifests itself in primary teeth; localized enamel hypoplasia, where spot-like defects are observed on individual teeth (usually 1-2); the problem is typical for permanent teeth; and focal enamel hypoplasia, where significant damage to primary or permanent teeth occurs, making them smaller than normal and their surface covered with rough spots and erosions.

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