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THE IMPACT OF MICRONUTRIENT DEFICIENCIES ON DENTAL HEALTH IN PREGNANT WOMEN

Abstract

Nowadays, the health of pregnant women is an important factor for the development of a healthy child. Physiological changes characteristic of the gestation period is accompanied by an increased need for essential trace elements and a redistribution of mineral resources. A lack of trace elements negatively affects the condition of teeth and periodontal tissues. The purpose of the article was to determine the effect of trace elements on dental health in pregnant women. The work uses methods of systematic analysis and synthesis of scientific research results. In the course of the work, an analysis of current scientific data on the effect of trace element deficiency on the condition of teeth was carried out. The biological mechanisms, clinical manifestations, and quantitative indicators of trace element levels in pregnant women were highlighted. It was shown that a lack of iron, zinc, magnesium, selenium, and fluoride contributes to the development of caries, gingivitis, bleeding gums, and impaired enamel mineralization. It has been established that an imbalance of trace elements affects the cells of the immune system and the microflora of the oral cavity in pregnant women. These changes affect the formation of dental tissues in the fetus. The results of the study indicate the need to determine the level of trace elements and monitor their levels during pregnancy. This will help to identify trace element deficiencies in a timely manner and prevent the development of dental diseases in pregnant women.

Keywords

Pregnancy, trace elements, dental health, tooth enamel, periodontium.

Introduction

The dental health of pregnant women remains a pressing medical and social issue due to the combination of hormonal, metabolic, and immunological changes that occur in the body during gestation. Numerous studies indicate a high prevalence of gingivitis, caries, and other inflammatory lesions of the oral cavity in pregnant women, even with satisfactory hygiene [1, 2, 3]. At the same time, dental problems are often underestimated by patients themselves due to unfavorable perceptions about the safety of dental treatment during pregnancy, which leads to the postponement of preventive and therapeutic measures [4].

Pregnancy is accompanied by significant physiological changes, including changes in mineral metabolism, an increased need for essential micronutrients, and the redistribution of nutrients between the mother and fetus. In this context, the condition of tooth enamel and periodontal tissues, which are sensitive to micronutrient deficiencies and changes in immune response, is of particular importance [5]. It has been proven that disturbances in the trace element balance can contribute to enamel demineralization, the progression of tooth wear, and increased caries susceptibility [6].

Among the trace elements that are crucial for dental health, special attention is paid to zinc, iron, fluorine, selenium, magnesium, and copper. In particular, zinc is involved in the processes of remineralization, inflammation regulation, and immune defense of the oral mucosa [7, 8]. Scientific research by Chen et al. [9] has shown associations between trace element levels and the prevalence of caries, confirming their role in maintaining the structural integrity of dental tissues. In addition, Wan-Ibrahim et al. [10] found that trace elements are involved in the formation of local immunity in the oral cavity and the modulation of inflammatory

reactions. It should be noted that the state of local immunity is important during gestation.

The influence of fluoride and other trace elements from food sources on enamel mineralization and the overall condition of the oral cavity occupies a special place [11]. Recent studies confirm the existence of a close relationship between the concentrations of toxic and essential elements in the mother's biological tissues and the structure of dental tissues in children, which indicates the long-term influence of trace element status during pregnancy [12, 13].

Experimental data also indicate the role of iron in the formation of caries resistance, in particular through its influence on tooth mineralization and metabolic processes in the tissues of the dento-maxillary system [14, 15]. Against this background, the relationship between micronutrient levels and the dental health of pregnant women becomes particularly relevant.

The aim of the study was to determine the effect of micronutrient deficiency on dental health in pregnant women.

Results

Micronutrient deficiency during pregnancy is a public health problem. Its burden and consequences for women's health are not always taken into account. During pregnancy, there is an increased need for micronutrients, which puts pregnant women at risk of developing deficiencies [16, 17]. The micronutrient content of pregnant women affects the formation of the structural integrity of teeth, the condition of enamel, and periodontal tissues. During pregnancy, there is a redistribution of micronutrients between the mother's body and the fetus. As a result, their concentration in pregnant women decreases. Such changes have direct consequences for the processes of enamel remineralization, inflammation regulation, and local immune defense of the oral cavity. Impaired proportions or the absence of certain elements can affect the content of other minerals and lead

to greater susceptibility of teeth to caries and other pathological agents [6, 18, 19].

Enamel is the outer layer of the tooth crown, which has a high level of mineralization. It is one of the most important structures of the tooth, both from a functional and aesthetic point of view. The structure of enamel develops during the process of odontogenesis. The chemical composition and structure of enamel are responsible for its resistance to chemical, thermal, and biological agents in the oral cavity of pregnant women. Magnesium ions play an important role in regulating the growth of hydroxyapatite crystals: they are adsorbed on their surface and are part of the hydration layer. Zinc and copper are necessary for enamel remodeling (demineralization and remineralization). This ability reduces the loss of enamel microhardness caused by bleaching and keeps the enamel morphology almost unchanged. In addition, copper ions inhibit plaque formation, enamel solubility in acid, and enamel remineralization, inhibiting bacterial growth and bacterial enzyme activity by oxidizing their key thiol groups [6, 18].

Nowadays, scientists have established that a decrease in serum iron levels in pregnant women below 10–12 μmol/L is associated with an increase in the incidence of caries, a decrease in enamel mineral density, and an intensification of inflammatory processes in periodontal tissues. Iron is necessary for the normal functioning of enzyme systems that support the metabolism of epithelial cells and the regulation of redox processes.

Zinc is considered a key regulator of the immune response of the oral mucosa. Thus, when its level is less than 9 μmol/L, the permeability of the epithelium increases, the sensitivity of the gums to bacterial action increases, and the repair processes in pregnant women slow down. Zinc deficiency is also associated with a decrease in the activity of antioxidant enzymes, which creates conditions for chronic inflammation in periodontal tissues. It has been established that magnesium plays a key role in the formation of the crystal structure of

hydroxyapatite and in maintaining the stability of tooth enamel. A decrease in its concentration below 0.7–1.0 mmol/L is associated with impaired mineralization processes, increased tooth abrasion, and an increased risk of developing non-carious lesions. Magnesium regulates microcirculation in gum tissue [6, 19, 20].

Selenium is part of the body's antioxidant system. It protects the cells of the oral mucosa from free radicals. A decrease in its level below 60 μg/L is associated with the activation of pro-inflammatory cytokines in periodontal tissues and more pronounced clinical manifestations of gingivitis. Selenium deficiency can contribute to increased inflammatory processes in the oral cavity of women during pregnancy.

Normal fluoride content reduces the risk of caries. Optimal fluoride intake during pregnancy helps increase enamel resistance to demineralization. At the same time, both its deficiency and excess can have adverse effects on the condition of hard tooth tissues. All this points to the need to control fluoride levels in the body of pregnant women [6, 21].

Copper, cobalt, and molybdenum are involved in enzymatic processes, collagen synthesis, and maintaining the integrity of periodontal connective tissue structures. An imbalance of these elements can contribute to the progression of inflammatory gum disease (Table 1).

It should be noted that micronutrient deficiency in pregnant women has a multifactorial effect on dental health. The highest level of association has been identified for iron, zinc, and magnesium. Their deficiency correlates with clinical manifestations of enamel and periodontal tissue damage. At the same time, elements with antioxidant properties, in particular selenium, play a modulating role in inflammatory processes. This is especially important in conditions of hormonally induced hyperreactivity of the gums during pregnancy.

A summary of clinical studies shows that a deficiency of essential trace elements has a clear quantitative relationship with the deterioration of the dental sta-

tus of pregnant women. In particular, epidemiological observations show that a decrease in serum iron levels in pregnant women is associated with an increase in the prevalence of caries and inflammatory gum diseases [1, 5]. Experimental data confirm that iron metabolism disorders are accompanied by a decrease in enamel mineralization and an increase in caries susceptibility, which is dose-dependent [14].

Table 1

Trace elements, mechanisms of action, and dental manifestations in pregnant women

Trace element	Biological mechanism of action	Generalized levels in pregnant women	Dental manifestations of deficiency
Iron	Enzymatic processes, redox balance	<10–12 μmol/L	Caries, gingivitis, decreased enamel mineralization
Zinc	Immune regulation, antioxidant protection	<9 μmol/L	Gum bleeding, slow healing
Magnesium	Hydroxyapatite formation, microcirculation	<0.7 mmol/L	Enamel abrasion, non-carious lesions
Selenium	Antioxidant protection, anti-inflammatory effect	<60 μg/L	Exacerbation of gingivitis, oxidative stress
Fluoride	Enamel remineralization	<0.5 mg/L in water	Increased risk of caries
Copper	Collagen synthesis, enzymatic activity	Decreased plasma levels	Weakening of periodontal tissues

Source: compiled by the author based on [5, 6, 7, 8, 10]

Zinc deficiency is another important factor in dental disorders during pregnancy. Studies on the role of zinc in oral immunity have shown that a decrease in its concentration correlates with an increased incidence of gingivitis, bleeding gums, and slowed regeneration of the oral mucosa [7, 8, 10]. Such changes are as-

sociated with a violation of the barrier function of the epithelium and a decrease in the activity of antioxidant enzymes.

Magnesium plays a key role in the formation of the crystal structure of enamel and the stability of hydroxyapatite. According to studies on the microelement composition of dental tissues, a decrease in magnesium levels is associated with increased enamel abrasion and the appearance of microstructural defects that increase the risk of non-carious dental lesions [6, 9]. These changes are particularly pronounced during periods of increased metabolic needs characteristic of pregnancy [5]. Selenium deficiency is associated with increased inflammatory reactions in periodontal tissues and increased oxidative stress, which complicates the course of gingivitis in pregnant women. The antioxidant properties of selenium are one of the main mechanisms of protection of the oral mucosa in conditions of hormonal changes in pregnant women [10, 12].

Fluoride levels also remain an important predictor of enamel resistance to caries. Insufficient fluoride intake from drinking water and food sources is associated with an increase in caries intensity, as confirmed by both population and clinical studies [11, 19]. At the same time, excessive fluoride intake can have adverse effects, highlighting the need for an individualized approach to its control during pregnancy.

The influence of the mother's micronutrient status on the dental health of her offspring deserves special attention. Cohort studies show that the concentrations of essential and toxic elements in the mother's blood during pregnancy correlate with the composition of dentin and enamel in children's primary teeth [12, 13]. Experimental models confirm that iron deficiency in pregnant women is associated with increased caries susceptibility in offspring, indicating a programming effect of intrauterine trace element imbalance [14].

It should be noted that the effect of trace elements on the dental health of pregnant women is not limited to the action of each element. It is realized through

complex interactions between different trace elements. The synergistic and antagonistic effects of trace elements alter the processes of enamel mineralization, inflammation, and immune reactivity of oral tissues. It has been established that iron deficiency is often accompanied by a decrease in the bioavailability of zinc, which potentiates disturbances in the reparative processes in the mucous membrane and exacerbates the clinical manifestations of gingivitis. At the same time, magnesium and fluoride demonstrate a complementary effect in the formation of a stable crystalline structure of enamel, and an imbalance of one of them can reduce the effectiveness of remineralization mechanisms even under conditions of adequate intake of the other [21].

Trace elements are necessary to maintain a healthy microbial balance in the oral cavity. It has been established that a lack of zinc and selenium is accompanied by an increase in the number of conditionally pathogenic microorganisms, in particular bacteria associated with periodontal diseases, which contributes to increased inflammation in the periodontal tissues. A disturbance in the trace element balance changes the local environment in the oral cavity, redox processes, the availability of nutrients, and the microenvironment, creating favorable conditions for the development of dysbiosis. Trace elements can be indirect regulators of the stability of the oral microbiome, and their deficiency is one of the risk factors for chronic inflammatory dental diseases during pregnancy.

The relationship between the mother's trace element status and the condition of the hard tissues of the teeth in children is important. A lack of trace elements in women affects the composition of dentin and enamel in the milk teeth of their offspring. Iron and zinc deficiency is associated with a tendency for children to develop caries. This indicates the long-term impact of intrauterine trace element deficiency on the formation of tooth resistance to caries.

In recent scientific studies by Lu et al. [14], Zampetti and Scribante [20], and Parsaei et al. [21], it has been established that trace elements are involved in

the regulation of systemic inflammatory and immune responses. Trace element imbalance is associated with physiological changes that are characteristic of pregnant women. This affects the development of dental diseases in pregnant women. Selenium and zinc can affect cytokine expression. Zinc and selenium deficiency in pregnant women affects gingivitis and contributes to the progression of periodontal disorders.

In general, the data obtained indicate that the micronutrient status of pregnant women is important not only for local processes in the oral cavity, but also for the formation of dental health in offspring. The interaction between individual micronutrients, their effect on the microbiome, and immune mechanisms create a regulatory system, the disruption of which increases the risk of developing dental diseases in both the mother and the child. This emphasizes the advisability of a comprehensive assessment of micronutrient status during pregnancy as part of the prevention of dental complications.

The results obtained are consistent with current understanding of the multifactorial nature of dental disorders during pregnancy and confirm the role of micronutrient status as one of the important, potentially controllable risk factors. It has been shown that a deficiency of essential micronutrients is not limited to deterioration of the enamel or periodontal tissues, but is accompanied by changes in the microbial composition of the oral cavity and peculiarities of the local immune response.

Decreased iron and zinc levels contribute to the development of caries, gingivitis, and inflammatory changes in periodontal tissues. Iron has been shown to regulate cellular metabolism and antioxidant defense systems. Zinc is necessary to maintain the protective function of the epithelium and the normal local immune response of the oral mucosa. Magnesium and fluoride are necessary to ensure the structural stability of enamel. Magnesium deficiency can reduce the effectiveness of fluoride-dependent remineralization processes. This explains the increased vul-

nerability of enamel even with sufficient fluoride intake. Such interactions between micronutrients emphasize the advisability of a comprehensive assessment of the nutritional status of pregnant women, rather than an isolated analysis of individual indicators.

The impact of micronutrient imbalance on the oral microbiome deserves special attention. Data on the association of zinc and selenium deficiency with dysbiotic shifts are consistent with current understanding of the role of micronutrients in regulating microbial ecology through changes in local immune and metabolic conditions. Disruption of this balance during pregnancy can increase the pathogenic potential of conditionally pathogenic microflora and contribute to the progression of dental diseases.

However, the results should be interpreted with certain limitations in mind. The quantitative indicators are based on data from scientific studies that differ in design, methods of determining trace element levels, and criteria for assessing dental status. At the same time, it is this approach that allows us to identify general patterns and form a comprehensive understanding of the role of trace elements in dental health in pregnant women.

Conclusions

The level of micronutrients in pregnant women is an important factor influencing the development of dental diseases. Micronutrients are necessary for normal enamel mineralization, maintenance of periodontal tissue health, and local immune response in the oral cavity during pregnancy.

The interaction between individual micronutrients and their effect on the oral microbiome form a complex multilevel mechanism of dental disease development, combining metabolic, microbiological, and immune factors. A lack of iron, zinc, magnesium, selenium, and fluoride is accompanied by an increase in the prevalence of caries, gingivitis, bleeding gums, and structural enamel disorders, which emphasizes the clinical importance of adequate micronutrient

supply during pregnancy.

Imbalances in the mother's micronutrient status during pregnancy can have long-term consequences for the child's dental health. They affect odontogenesis and the development of caries resistance in later life.

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