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RESEARCH ARTICLE

ROLE OF ZINC IN ORAL HEALTH: A REVIEW

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ABSTRACT

Nutrients are the substances present in food which helps in the nourishment of the body tissues and are essential for the growth and development of the body. Without sufficient nutrients the body may not function optimally and severe inadequacy of these nutrients can lead to many diseases. Oral health and nutrition have a synergistic multi directional relationship. Zinc is a trace element of valuable importance which is present naturally in oral cavity at various sites such as dental plaque, dental hard tissues and saliva. Oral manifestations can be the presenting symptom for zinc deficiency, and thus a careful medical history and proper examination is critical to ensure that diagnosis and treatment are not delayed. This review appraises the biological functions of zinc and its role in oral health and in progression of various diseases.

INTRODUCTION

Adequate and appropriate nutrition is essential for all the metabolic cells and tissues of the body to preserve health of the human body. Micronutrients includes trace elements, vitamins, and antioxidants which has a vital role in continuously ongoing regenerative processes and coping with oxidative stress in the body tissues (Enwonwu *et al.,* 2002). The manifestations of deficiency of micronutrients on the oral health are vast and can leads to defects in the dental hard tissues as well as changes in oral mucosa. Trace elements are chemical micronutrients which are required in minute quantity but play a vital role in maintaining integrity of various processes occurring within body. One such micronutrient is Zinc which is a common element in human and natural environment which play a very important role in various biological process. Zinc has certain chemical properties that make unique and important in biological systems. The human body contains about 2g of zinc, of which approximately 60% is found in muscle tissue, 30% in bone and 5% in skin (Thomas and Bishop, 2007). Zinc is essential for both in the synthesis and actions of the hormones, which are intimately linked to bone metabolism. In vitro studies have shown that zinc (Zn) stimulates osteoblastic bone formation. It has been reported that zinc is effective against common prevalent oral health problems such as dental caries, gingivitis, periodontitis and malodor and low zinc levels in the serum can be used as an essential tumor marker. Due to the wide prevalence of zinc deficiency and the multitude of zinc's essential biological functions, nutritional correction of zinc deficiency may have a significant impact on different aspects of human health.With this background in mind, this review summarizes the role of zinc in oral health.

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Metabolism of zinc

Zinc gets absorbed in the small intestine, which regulates homeostasis of zinc through changes in the fractional absorption of dietary zinc and excretion of endogenous zinc in pancreatic juice and gastrointestinal secretions. During digestion of food zinc is released as free ions. These liberated ions then binds to endogenously secreted ligands before they get transport into the enterocytes in the duodenum and jejunum. Presence of specific transport proteins facilitate the transport of zinc through the cell membrane into the portal circulation. Portal system carries absorbed zinc into the liver directly, and then releases it into the systemic circulation for delivery to other body tissues. Around 70% of the zinc in circulation is bound to albumin, and any condition which alters serum albumin concentration can also effect serum zinc levels (FAO/WHO, 2004).

Role of zinc in systemic health

Zinc has various biological functions that can be grouped into three categories: catalytic role, regulatory role, and structural roles. It is required for the catalytic activity of a many enzymes. It plays a vital role in immunity, synthesis of protein and DNA and cell division. Zinc is has a role in sense of taste and smell. It also essential for normal growth and development during pregnancy, childhood, and adolescence. Allegedly, it also possesses antioxidant properties and thus may play a role

in healing after an injury and protecting against accelerated aging. Zinc ions are also effective antimicrobial agents (Bhattacharya *et al.,* 2006).

Growth and Development: Zinc play critical role in tissue growth, wound healing, taste, growth and maintenance of connective tissue, immune system, prostaglandin synthesis, bone mineralization, adequate thyroid function, blood clotting, foetal growth and sperm production.

Immune system: Zinc is essential for the immune system and zinc deficiency has dramatic implications for immune function. Zinc supplementation has been shown to improve the cell-mediated immune response of healthy elderly.

Antimicrobial Effect of Zinc: Zinc has antimicrobial properties against different bacteria such as Streptococcus mutans. Zinc is taken up by the bacteria by export and uptake systems regulated by their own regulators, among them are Resistance-Nodulation Division multi drugs efflux transporters, P-type ATPases and cation diffusion facilitators and also peroxide activated system. Cytoplasm and glycolytic enzymes of the bacterial cells are the common targets of zinc (Phan *et al.,* 2004).

Zinc as an Anti-oxidant It is an efficient antioxidant as it reduces the production of toxic agents such as hydrogen peroxide which has noxious effects against the host cells. Zinc deters the respiration in Fusobacterium nucleatum and other oral microflora to stop the production of reactive oxygen.

Dietary sources of zinc and recommended dietary allowance

Zinc is found in animal food like meat, milk, fish, chicken and cereals, eaten alongside vegetables to enhance zinc absorption. Plant sources of zinc are cooked dried beans, sea vegetables, fortified cereals, seeds, soy foods, nuts, peas.

Table 1. Showing Recommended dietary allowance of zinc (World Health Organization, 1996; Kulkarni *et al.,* 2014)

Age Group	RDA
Infants and children 7 months old to 3 years old	3mg/day
4 to 8 years old	5mg/day
9 to 13 years old	8mg/day
Girls 14 to 18 years old	9mg/day
Boys and men aged 14 and older	11mg/day
Women 19 years old and above	8mg/day
Pregnant women	11mg/day

Role of zinc in oral helth

Role in dentistry: Zinc is used in mouth rinses as an anti-bacterial agent which serves as an agent to control the development of dental plaque, calculus, malodor and bleeding gums. In the field of Nano-therapeutics has lately evoked its interest in controlling the development of oral biofilms by using biocidal nanoparticles. Zinc is as an effective antibacterial agent which can be incorporated in the toothpaste where it helps to control the plaque and calculus formation. Zinc can also be a significant constituent of restorative materials, amalgamating small amounts of Zinc oxide nanoparticles into the composite resin may boost its mechanical properties.

Lichen planus is a chronic inflammatory condition affecting particularly the immuno-compromised individuals. Zinc plays a significant role in the growth of epithelium. Its deficiency is concomitant with immunity and impaired wound healing results in the inhibition of lymphocytes, particularly T-lymphocytes which are of main concern in immunologic-based disorders like Lichen Planus (Shankar *et al.,* 2000).

In Immuno-compromised person: Individuals who are undergoing chemotherapy have a high risk of developing oral mucositis. Zinc sulfate, a form of zinc was found to be a high effective option in individuals who are subjected to high dose of chemo agents (Mehdipour *et al.,* 2011).

Deficiency of zinc

- **Primary deficiency**: It is caused by a specific absorptive defect which is present in acrodermatitis enteropathica or by insufficient nutrition.
- **Secondary Deficiency**: Zinc deficiency occurring due to diseases of the gastrointestinal tract causing diarrhea and malabsorption. Such cases are called Conditional or Secondary Zinc deficiency.

Primary zinc deficiency

Acrodermatitis enteropathica: It was discovered by the Swedish dermatologist "Thore Brandt" in 1936. It is the only inherited Zinc deficiency disease in man, transmitted as an autosomal recessive trait. The disease starts around 4-6 weeks after weaning. The child turns peevish, withdrawn and photophobic, develops a vesiculobullous dermatitis on hands, feet and peri-orificial regions and scalp hair is lost. Diarrhea is often present with stunted growth and there is an increased susceptibility to infections with poor wound healing (Islam and Hasan, 2000).

Secondary zinc Deficiency

Zinc depletion syndrome: Adults who is Zinc deficient develop zinc depletion syndrome within 3 months. Where there is disturbed bowel function the Zinc loss is increased, and if combined with a decreased absorption and low dietary Zinc intake-zinc depletion will develop. The Zinc depletion syndrome was are identified originally because of the acrodermatitis enteropathica-like skin lesions.

Effects on growth and development: One of the most common zinc deficiency is the impairment of physical growth and development. This effect is of most significance during the periods of rapid growth such as pregnancy, infancy and puberty during which zinc requirements are highest (Brown *et al.,* 2004). DNA requires Zn in phase II of G l cell cycle period. This Zn related protein influences the synthesis of some enzymes required for DNA synthesis. Two important enzymes that have been researched in this regard are DNA polymerase and thymidine kinase. Zn is essential for DNA polymerase activity. Thymidine kinase is the enzyme that changes thymidine to deoxythymidine monophosphate which is the precursor of DNA in the DNA synthesis pathway. The enzymatic defects will result in impaired DNA synthesis. Deficiency of zinc can impair DNA synthesis resulting in ultimate growth retardation.

Risk of infections

a. **Diarrhea**: Diarrhea is characteristically, although not inevitably, a prominent feature of acrodermatitis enteropathica. The link between zinc deficiency and diarrhea could be impairment of the immune system and of intestinal mucosal cell transport. A causal relationship between zinc deficiency and diarrhea is indicated by the beneficial effects of zinc supplements and concurrent increase in growth velocity (Brown *et al.,* 1998).
b. **Pneumonia**: Community zinc supplementation studies in children have demonstrated a substantial and statistically significant reduction in the prevalence of pneumonia in developing countries (Bhutta *et al.,* 1999).
c. **Malaria**: Infections such as malaria may be more sensitive to zinc deficiencies because the killing by macrophages is inhibited. Malaria is associated with a rapid decline in CD4 cell count that produce interferon γ and interleukin 2, but not interleukin 4, can reduce parasites in vivo. It is uncertain to what extent oral supplementation with zinc can reduce episodes of malaria in endemic areas. According to some studies, malaria also appears to be reduced by zinc supplementation (Shankar *et al.,* 2000).

Oral manifestations

Dental Caries: Zinc is important for the mineralization of the enamel and is known to reduce the susceptibility to dental caries[15]. Deficiency of Zinc leads to demineralization of the enamel causing dental caries.

Periodontal disease: Dietary deficiency of Zn leads to poorer periodontal health. Zinc acts as a cofactor in many enzyme-controlled processes. Particularly, it modulates the processes of auto-debridement and keratinocyte migration during wound repair. Furthermore, it also exerts an antioxidative effect by scavenging ROS in addition to neutralizing bacterial toxins. Deficiency of Zinc alters the thickness and keratinization of oral mucosa which becomes more susceptible to infections. Furthermore, deeper periodontal pockets and thicker palatal tissues have been reported in Zn-deficient rats (Chow and Eanes, 2001). Zinc is known to inhibit the crystal-growth of hydroxyapatite and its reported precursors dicalcium phosphate dihydrate and octacalcium phosphate. This ability of zinc to modify the crystal-growth pathways of calcium phosphates has been exploited to control calculus formation. But deficiency of zinc leads to increased calculus formation (Orbak *et al.,* 2017).

Depapillation of tongue: It includes changes in the epithelium of the tongue, such as thickening of epithelium, increased cell numbers; impaired keratinization of epithelial cells; increased susceptibility to periodontal disease; and flattened filiform papillae. Zinc deficiency in human is associated with loss of taste and smell acuity and impaired wound healing. Zinc deficiency also results in congenital defects such as skeletal abnormalities, especially cleft palate and lip.

Figure 1. Depapillation of tongue

Figure 2. Recurrent apthous stomatitis

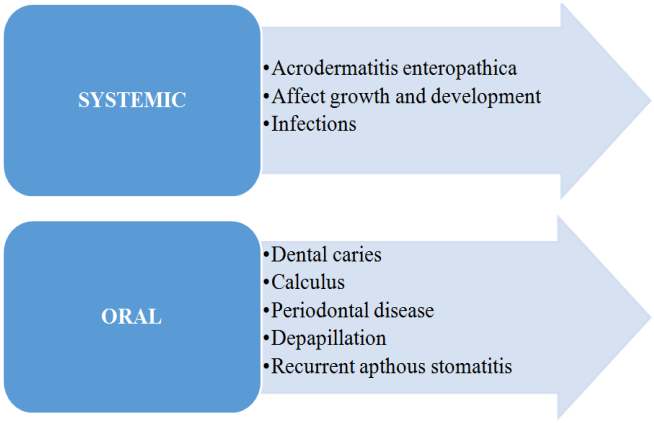

Figure 3. Effect of Deficiency zinc on health

Recurrent apthous stomatitis (RAS): Deficiency of zinc may leads to RAS, this may be due to ability of zinc to stimulate the production of IL-1, IL-6 and TNF-α in peripheral blood mononuclear cells and separated monocytes. Production of cytokines gets disrupted in zinc deficient individuals, low levels of serum zinc correlate with a reduction in production of Th1-type cytokines. Local tissue damage at the early stage of apthous formation occurs in the response to an abnormally stimulated cascade of cytokines. A study was conducted on rodents which stated that zinc deficiency can result in parakeratosis of oral mucosa. Thickening of the buccal mucosa is a one more common manifestation along with loss of filiform papillae (Das, 2012).

Therapeutic measure

Medical management: Zinc compounds such as zinc sulphate, zinc gluconate, or zinc picolinate may be added to the enteral preparations. If oral ingestion is possible, these zinc compounds may be administered orally mixed with juices, or in the form of enterosoluble capsules. In adults, a daily zinc dose of 150–200 mg (as the zinc compound) is usually sufficient.

Diet: Dietary changes and supplements are used to treat zinc deficiencies. Food sources of zinc are Oysters, red meat and poultry products. Other good food sources include beans, nuts, certain types of seafood (such as crab and lobster), whole grains, fortified breakfast cereals, and dairy products.

Conclusion

Oral cavity is a not just a gateway for delicacies. The oral cavity is thought to be a window to the body because oral manifestations accompany many systemic diseases. In many conditions, oral manifestations precedes lesions at other locations. Thus oral manifestations of zinc deficiency must be properly recognized. A correction of this deficiency will have a great impact on human health. Dentists should be familiar with the zinc which is a very important trace element with varying manifestation that can affect the oral cavity, so that appropriate referral can be made.

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