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Fluoride and Fluorosis: Beyond Teeth

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ABSTRACT
Fluoride is a chemical element that is highly reactive with hydrogen and metals. It is ubiquitous in water, volcanic areas, acidic soils, vegetation, animals and food. It is necessary for humans, as it is considered a micronutrient that plays an important role in maintaining the structureand physiology of bones and teeth. Since the early 1990s, fluoride has been recognized as an essential element in the prevention and treatment of dental caries, provided it is used in adequate doses, as it has properties that affect the mineral dynamics of teeth and bacterial activity. However, excessive use for long periods can cause serious harm to health. This article presents some biochemical characteristics of fluoride,the mechanisms of actionon the tissues and systems of the human body and the consequences caused by excessive consumption, as well as some suggestions for preventive measures.
Keywords: Fluoride-Dental fluorosis-Bone fluorosis-Fluoride poisoning

I. INTRODUCTION

Fluorine (F) is an electronegative chemical element with atomic number 9 in the periodic table and is highly reactive with hydrogen and metals. It is not found in its free form in nature. It is a natural gas that exists only in combination with other elements, with low stability, rapidly soluble in water in its ionic form and is ubiquitous in water, volcanic areas, acidic soils, vegetation, animals and food[1,2]. Its consumption is necessary for humans, as it is considered a micronutrient that plays an important role in maintaining the structure and physiology of bones and teeth [3]. Since the early 1990s, fluorine has been recognized as an essential element in the prevention and treatment of dental caries due to its properties on the mineral dynamics of teeth and bacterial activity [4]. From 1945 onwards, it began to be incorporated into drinking water for consumption by the population [5,6], and is considered safe when ingested at recommended levels, as studies have shown

In turn, fluorosis is recognized worldwide as a social and public health problem that compromises the physical and mental state of millions of people around the world [3], making it necessary to widely publicize its causes and clinical consequences, since its recognition is usually late until the disease develops to an advanced stage with major clinical repercussions.

Fluorine

Fluorine is a chemical element widely distributed across all continents, with greater concentration in areas of volcanic soil, contaminating air, water, vegetables and animals.Water is the main source used by living beings, but it can also be found in foods such as: fish, shrimp, seafood containing edible bones (sardines), fruits, vegetables, gelatins, mechanically deboned meat (chicken nuggets) [9], tea leaves, tomatoes, grapes, spinach, elderberries and soft drinks. Inaddition, other sourcesmay be oral hygiene products, agrochemicals, pesticides, medicines, ozone depleters, coal burning [5,7,8,10,12], manufacturing of iron, steel, zinc, aluminum, phosphorus, cement, bricks, chemical fertilizers [11,13,14].

The absorption of F may begin in the oral cavity. However, oral absorption is mostly done by the stomach, due to the acidic pH, and the proximal part of the intestine, by passive diffusion, occurring rapidly, reaching a peak between 30 and 60 minutes [8,15] and the concentration falling within 6 hours. Due to its high affinity for positive elements, the absorption of F may be reduced by calcium contained in food [16,17]. 99% of the absorbed amount is aggregated to mineralized tissues [1,6,13] and 1% in soft tissues, with the largest amount being retained by young bones compared to those of adults [1]. Children retain 80% to 90% of was absorbed, while adults retain about 50% [8,9]. Other absorption routes may be through contact with the skin and through the lungs, through aerosols [11,18]. Excretion is rapid and predominantly via the kidneys, which highlights the important role of thekidneys in controlling the balance of Fin the body. Saliva, feces and sweat can also excrete small amounts of F [19,20].

Mechanisms of toxicity

Fluoride alters the metabolism and enzymatic activity of soft tissues, crosses the cell membrane and causes metabolic, structural and functional toxicity in practically allorgans [14, 21]. It also acts through other mechanisms such as protein inhibition, pH changes, damage to organelles, electrolyte imbalance, compromising hormone function, causing damage to genetic material and apoptosis [8,10,14,22,23]. The total concentration of fluoride in the body increases with age [13] and the effects may vary according to the dose, exposure time,ambient temperature, altitude, nutritional status, blood pH and renal function capacity [5,6,9,6,17,23]. While plasma concentrations of fluoride are low, the highest concentrations can be found in teeth and bones.

Effects of excess fluoride on the body

1. Dental fluorosis

Fluorosis is a defect in the development of dental enamel related to excessive fluoride consumption, which makes it more porous and poorly calcified, developing stains, sub mineralization spots, depressions and streaks. The critical window for the development of dental fluorosis in response to excessive fluoride intake ranges from birthto eight years of age [24,25,26]. Fluoride compromises the amelogenesis process by interfering with the activity of ameloblasts (cells responsible for enamel formation) and proteins [26,27] such as amelogenin, causing changes that, although permanent, can be subjected to some types of aesthetic treatments such as: dental whitening, microabrasion, bonding of composite resin and use of crowns [28]. Exposure to high plasma levels of fluoride during amelogenesis results in the formation of hypomineralized porous enamel. In severe cases, the porosity may extend toward the dentin-enamel junction. According to the amount and duration of F ingestion, the lesions can be classified as mild, moderate or severe, ranging from superficial changes in the enamel composed of tiny white spots to corrosion, manifested by dark yellow-brown spots. Although dental fluorosis does not cause pain or discomfort, the impact caused by the appearance ofthe teeth is responsible for inhibition and embarrassment of people in many everyday situations [4,29,30].

2. Bonefluorosis

Fluoride has a high affinity for positive charges, especially calcium. Therefore, tissues with a lot of calcium attract large amounts of F, which are deposited as calcium fluoroapatite crystals [14].It actsonosteo blasts, stimulating proliferation and increased deposition in spongy bones, inhibiting osteoclast activity and altering the bone crystal structure, compromising the balance between bone formation and resorption [18,20]. As a consequence, bone fragility, skeletal dysmorphia and a greater risk of fractures occur [8]. Spongy bones (ribs, pelvis and vertebrae) are more affected than long bones [13]. The most characteristic structural changes influorosed bones are: increased bone mass and density, osteosclerosis, osteophytosis, exostosis, osteoporosis, mineralization of tendons and ligaments, deformities, compressions, fusion of vertebrae, joint stiffness, limitedmovement, fractures [7,14,16,19], arthritis, reduced movement, paralysis. Difficulties in fracture recovery may occur due to increased calcineurin activity, which inhibits osteoclast function [21]. In conditions that reduce urine pH, fluoride is reabsorbed in the renal tubules and returns to the blood, which may aggravate fluorosis [22].

3. General effects

Due to its ability to cross the blood-brain barrier, F can accumulate in the cerebellum, hippocampus, motor cortex, and pineal gland [9,23]. It compromises thyroid function, the gastrointestinal (vomiting, diarrhea), reproductive (compromising male fertility by preventing spermatogenesis), cardiovascular, and urinary systems [11,14,24]. It alters menstrual cycles and compromises the uterus and ovaries [16], causes premature aging (due to oxidativestress), delayed puberty, and increases the activity of the parathyroid gland, alkaline phosphatase, and calcioneurin [21]. Due to its ability to cross the placenta and itsneurotoxicity, F causes neurological damage to the fetus [21]. High concentrations of F in the body are also related to cognitive impairment, attention deficit hyperactivity disorder, and low intelligence quotient (IQ) in children [9,12,14,21,22,25,26,27].

II. CONCLUSIONS

Although fluoride is a micronutrient necessary for human metabolism, excessive amounts and chronic use can cause great harm to the body. In order to identify the changes, it is necessary to carefully assess the clinical history, socio-environmental conditions and epidemiology of fluorosis, since the diagnosis may be delayed or not even considered, sincethe clinical picture may simulate arthritis or other diseases in adults [1,14,30], and rickets and renal osteodystrophy in children. With the development of agriculture and the modernization of industry, fluoride pollution

has become one of the important factors in environmental contamination, further aggravating health conditions due to its accumulation. Therefore, studies on mechanisms of action, consequences and treatment should be encouraged in order to better understand all the changes that can affect living beings [31,32,33], highlightingmainly the groups at greatest risk, such as children, pregnant women and the elderly. Considering that changes in teeth and bones are irreversible and untreatable, considerable investment should be made in prevention and environmental control. Measures such as water defluoridation, control over water and food intake, consumption of foods with vitamin C, vitamin E, antioxidants and calcium, and nutritional education programs on the harm causedto healthbyexcess fluoride shouldbeencouraged and supported by society as awhole [34], in addition to investments in the development of technological processes such as nanofiltration, reverse osmosis and advanced oxidation methods.

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