

Contents lists available at KulDevWeb

Current Multi Science

journal homepage: www.current-multiscience.kuldevpublication.com

Review Article

Fluoride metabolism, toxicological consequences, and dental health

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ARTICLE INFO

Article history:

Received 01 July 2024

Accepted 13 July 2024

Available online xxxx xxxx

Keywords:

Dental caries,
Dental fluorosis
Metabolism
Fluoride

ABSTRACT

A naturally occurring substance, fluoride has several effects on human health. The current papers address the substance's metabolism and toxicity, as well as our current understanding of its action and potential use as a secure agent to prevent tooth caries. Levy's longitudinal investigations have shown that milk derivatives, water, fish and shellfish, poultry, toothpaste, and other oral products, as well as Teflon coating that contains fluoride, are the main sources of fluoride consumption. However, their findings showed that because of differences in consumption and the variety of items available, intake levels at early ages display large ranges. Drinking water infused with milk formulae can raise the fluoride content and, thus, the risk of dental infections. Also covered is the connection between dental fluorosis development and high fluoride consumption during the stages of tooth enamel production.

Selection and peer-review under responsibility of scientific committee of editorial board members of Current Multi Science and author(s) and suggested reviewer.

1. Background

Since fluorine (F) is the most electronegative and reactive nonmetal, it seldom ever exist in nature and its elemental form. Instead, of combined with all other elemental products to produce fluorides, with the exception of noble gases and oxygen. Naturally the fluoride was occurring and present in all small level in all water sources. The majority of fluoride's entry into the body occurs through that gastrointestinal tract, where it is rapidly absorbed in the stomach without the any aid of specialized enzyme systems.1. It travels over epithelia as hydrogen fluoride, or un-dissociated acid. The physiological behavior of fluoride is explained by hydrogen fluoride's infusibility. According to recent research, most fluoride absorption happens in the small intestine there is not pH dependent; in addition to passing through the stomach un dissociated acid. There is evidence to support the existence of several carrier-mediated, pH gradient-dependent pathways for intestinal fluoride transport 2. The stomach's acidity has a direct impact on how quickly fluoride is absorbed from it.3However, a number of other variables, such as the ingested fluoride compound's solubility, affect the rate of absorption. Fluoride molecule that was more solubles, such sodium fluoride (NaF).

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Volume-1; Issue-1; July-2024

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Hydrogen fluoride, absorb more quickly than those that are less soluble, like calcium fluoride (CaF_2) and magnesium fluoride (MgF_2). Plasma fluoride levels rise as soon as fluoride is absorbed (at 10 minutes), peaking at 60 minutes. It takes 11 to 15 hours for basal levels to restore. Fluoride is quickly deposited in the skeleton or eliminated by the kidneys when it reaches plasma. Aside from age, other variables that affect fluoride skeletal absorption include bone remodeling and modeling activity.

The age of the person has an inverse relationship with the amount of fluoride that is maintained in the bones. When fluoride is absorbed for the first time in people who have never been exposed to it before, saturation is attained. Saliva secretes fluoride, and when plasma levels rise, so do salivary levels. Salivary levels are crucial for fluoride's function as a preventative agent against dental cavities, even though they only range from 0.01 to 0.06 ppm for those exposed to fluoride. The kidneys are mostly responsible for eliminating the fluoride that is not retained in bone, with feces accounting for a little amount. Numerous investigations have determined the levels of fractional urine fluoride excretion for both adults and children. More recent research has estimated that young, healthy adults' fractional urinary fluoride excretion falls between 78% and 79%.

The Toxicity of Fluoride:

Too much fluoride in the diet can be harmful. It is advised by the American Dental Association that a maximum of 111 mg of fluoride (259 mg of sodium fluoride) be administered at time 9. The literature describes fatal dosages ranging from 7 to 16 mg/kg of weight of body. The minimal fluoride doses that might produce toxic signs and symptoms, including death, has been defined at 15 mg/kg. Infants have died after taking as little as 250 mg. Acute fluoride poisoning frequently manifests as nausea, vomiting, and a decrease in blood calcium levels, which can result in either localized or widespread muscular tetany. Additional symptoms include discomfort and cramping in the abdomen, rising hypocalcemia and hyperkalemia, which can result in unconsciousness, seizures, and cardiac arrhythmias. When someone consumes too much fluoride, they usually die within 4 hours; if they live for 24 hours, their prognosis is considered favorable. Fluoride has main 4 toxic effects: (a) cellular poisoning; (b) burning tissues (it corrodes when it comes into contact with moisture and forms hydrofluoric acid); (c) inhibiting cardiac function (by causing an electrolyte imbalance that results in hyperkalemia) and d) inhibiting nerve function.

Fluorides and the Prevention of Dental Caries: It is commonly known that fluoride lowers the incidence of dental cavities. A site's unique dental plaque composition and metabolism, which are impacted by biological determinants like as saliva, food, and maybe hereditary factors, determine the development of dental caries on that site. Acid production occurs throughout time as a result of the metabolism of dental plaque. These acids react with the tooth enamel's surface, demineralizing or eliminating minerals. The pH of the area around the tooth enamel rises as a result of other ions and proteins in the oral environment neutralizing those acids. By doing this, the circumstances are set up for minerals to re-mineralize tooth tissues. On the other hand, a loss of mineral from the tooth surface and the emergence of dental caries occur when demineralization-promoting situations are common. Fluoride reduces the pace of dental enamel demineralization and increases the rate of enamel remineralization, as several studies have demonstrated. This lowers the incidence of dental caries and delays or reverses the course of existing lesions.

The current knowledge of fluoride's mode of action suggests that its primary impact is topical, and that this depends on fluoride being present in sufficient concentrations in the tooth plaque/enamel interface throughout the development and reversal of caries. Fluoride also affects the metabolism of dental plaque bacteria, which is a secondary mechanism. Nonetheless, there is ongoing discussion on the relative significance of fluoride's direct effects on bacterial metabolism. Lastly, it is known that there is a little amount of fluoride incorporated into the enamel crystals before teeth erupt, which may strengthen the enamel's resistance to acid solubility.

According to our current understanding of the mechanism of action for fluoride-induced caries prevention, fluoride mostly operates topically rather than systemically, meaning that it prevents caries throughout an individual's life, not just when teeth are growing. It has been shown that the best work to utilize fluoride to dental cavities preventions is in toothpaste. Public health benefits from systemic sources of

fluoride, such as drinking fluoridated water, which increase fluoride exposure. Populations without access to topical fluorides or routine dental care stand to gain most from the 0.7 parts per million addition of fluoride to public water sources.^{17–18}.

Fluorides and Dental Fluorosis:

During tooth development can cause dental fluorosis due to too much fluoride, which is a hypomineralization of dental enamel.^{19–20}. A window of susceptibility was estimated for the central maxillary incisors based on findings from an epidemiological study conducted in Hong Kong, China, whereby fluoride levels in the water were adjusted downward, allowing researchers to pinpoint specific times of excessive fluoride intake for groups of children.^{21–22} The first two years of life are thought to be covered by the window of vulnerability, according to more recent studies.^{23–24} It is commonly known that fluoride taken orally affects tooth enamel as it forms. The majority of research that has shown these effects was carried out in areas where fluoridated water supplies are available.

Early fluorosis symptoms appear as opacities on the enamel surface at 1.2 parts per millions in the water supply. The indications get worse as the dosage goes up, and at around 10.8 parts per millions, the porosity of the enamel is weakened, causing huge sections of enamel to fracture following eruption. tooth fluorosis develops at the cellular level in response to fluoride concentrations in the extracellular fluid surrounding the growing tooth enamel.^{25–26}. We still don't know the precise tissue concentrations at which fluoride starts to work. In published research, tissue fluoride concentration has reported in a variety of ways, and in many cases, not at all. According to experimental findings, the effects of increasing fluoride dosages on dental tissue appear to follow a linear relationship. In addition to fluoride intake, a number of epidemiological studies have suggested that other variables influence the development of dental fluorosis. The risk of developing dental fluorosis has been linked to a number of other factors, including systemic diseases and malnutrition that affect an individual's physiological state and the use of prescribed medications that may alter the body's acid-base balance. Residency at high altitudes may also be associated with a higher prevalence and severity of dental fluorosis.^{27–28}

Summary

Numerous elements of fluoride metabolism and toxicity have been well researched. Still, further research is required. Fluoride has been proven to be a considering the present knowledge of its toxicity and mode of action, a safe and effective drug in the prevention of dental caries at appropriate dosages.

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