CHAPTER

21

Fluorides in Caries Prevention

Fluorides play a pivotal role in the prevention of dental caries. It is the most effective and most extensively tested of current anti-caries agents. The natural occurrence, metabolism, mechanism of action and toxicology has been thoroughly studied as any other element. It is one of the best armamentariums used in the prevention and control of dental caries.[6]

NATURAL OCCURRENCE OF FLUORIDE

Fluorides in Minerals and Earth's Crust

Fluoride is an extremely reactive member of the halogen group of elements. Fluoride is widely distributed in the earth's crust. It is the 13th most prevalent element and is found in both igneous and sedimentary rocks.

In nature, fluorine occurs most abundantly in association with the elements calcium, as fluorite or fluorspar, CaF_2; calcium and phosphorus, as fluoroapatite, $Ca_{10}(PO_4)_6F_2$; and aluminium as in cryolite Na_3AIF_6. Fluorides occur in certain silicate minerals (topaz and lepidolite) as a result of isomorphous replacement of the hydroxyl by fluoride ion, which is about the same size and bears the same charge.

Fluorides in Water

By virtue of dissolution, fluorides occur in most springs, wells, seawaters, and plants. The ubiquitous presence of fluorides in nature makes it an inevitable component of human diet. Fluorides are present in trace quantities in all surface and underground waters. The concentration of fluorides is negligible in rainwater and high in some lakes and wells. The fluorides contained in drinking water is commonly the largest single contributor to the daily fluoride intake.[5]

Fluorides in Food

The fluorides in the soil are absorbed by plants to a degree determined mostly by the type of plant and secondarily by the fluoride compounds in soil and the moisture conditions. Plants are selective in the amount of fluoride they absorb.

Seafood

Sardines, salmon, mackerel and other fish contain about 20 ppm of fluoride on a dry weight basis. Seafood is rich in fluorine since the oceans contain about 1 ppm of fluorine. The high fluoride level in fish is attributed to the fluoride in the skins and in bones, which become edible during canning.

Shellfish, or the flesh from large fish, contains only about 1 ppm of fluoride.[6]

Rock Salt

The fluorine content of rock salt ranges between 40 and 200 ppm. In India, this form of salt may be consumed at maximum intake of 20 g daily. These source alone could supply between 1 and 4 mg fluoride to the daily diet and this may contribute to the endemic fluorosis in some parts of India.

Tea

The tea plant family theaceae, including tea and camellias, stores fluoride. Dried tea leaves contain about 100–400 ppm fluoride. An average infusion of tea contains between 1.4 and 3.6 ppm fluorides.

Leafy Plants

The normal levels of fluoride in plants other than in tea family is about 2–20 microgram/gram of dry weight. Leafy vegetables, such as cabbage and lettuce, contain about 11–26 microgram fluoride.[5]

Plants grown in acidic soils have a higher fluoride content than those grown in lime-containing basic soils.

Airborne Fluoride Emissions

Fluoride emissions are heaviest in the vicinity of industries involved in the production of aluminium from cryolite or phosphate fertilizers. Airborne fluoride in such areas occurs as particulate dusts, as hydrofluoric acid or gaseous fluorine.

Fluorides in Drinks

Fresh fruit juices have a low fluoride content of 0.1 to 0.3 mg/litre. Human breast milk has a low fluoride content, less than 0.02 mg/litre. The fluoride content in soft drinks and mineral water reflects the same level as the water from which it is produced.

Beer is normally low in fluorides ranging from 0.3 to 0.8 mg/litre, in contrast to wine that can have fluoride levels of the order of 6–8 mg/litre.

Fluorides in Pharmaceutical Products

An increasing number of pharmaceutical products contain fluorides in organic and inorganic form. The products such as sodium fluoride tablets, vitamin pills, fluoride dentifrice, fluoride gels and solution are widely used for caries prevention.

Metabolism of Fluoride (Fig. 21.1)

The significance of fluoride in nutrition is related to its regular presence in small amounts in foods and in all tissues of the body. The advent of water fluoridation as a public health measure for partial reduction of caries and the continued and increasing use of other fluoride formulations makes it essential that its metabolism be known. By understanding the fate of ingested fluoride it is possible to quantitate safe and unsafe levels of ingestion from air, water and foods.[6]

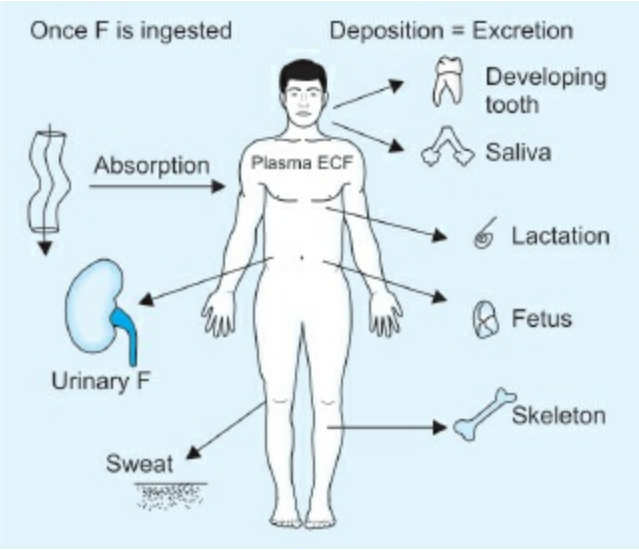

Fig. 21.1: Metabolism of fluoride[2]

Estimated Daily Intake of Fluoride

Several estimates have been made of the daily intake of fluoride from food and water. The variation reflects different dietary patterns between races and countries. Two factors that contribute most to the daily intake are fluoridated water and fluoride-rich foods such as fish. The average daily intake of fluoride by adults from dry food substances is in the range of 0.2–1.8 mg and the average daily intake from water containing 1.0 ppm fluoride is about 1.5 mg.The total daily intake for adults being in the 1.7–3.3 mg range.[5]

Absorption of Fluoride

Most fluorides are absorbed rapidly and transported in the body and subsequently excreted as the fluoride ion. About 86–97% of ingested fluoride is absorbed. The main factors influencing absorption are species variation, concentration of fluorides ingested, solubility and degree of ionization of the compounds, and other dietary constituents, such as calcium, which may form insoluble salts with fluoride. The rate of absorption increases with starvation and presence of fats. The presence of calcium, magnesium and aluminium decrease absorption. A comparison of rates of absorption of fluoride in milk and water indicates a significant reduction in fluoride absorption from milk during the first hour, but thereafter absorption continued at higher levels for longer periods of time.

Fluoride in Blood Plasma

There is evidence that plasma fluoride levels increase slightly with age. Plasma fluoride levels also increase in the presence of renal failure.

Human blood contains fluorine in both organically bound and inorganic forms. It has been suggested that the former originates from the environment and that it does not seem to be related to the inorganic fluoride content. Almost all fluoride in plasma is in ionic form and is not bound to any macromolecules. The plasma half-life of fluoride is reported to be 4–10 hours.

Blood plasma fluoride levels begin to rise about 10 minutes after ingestion and reach maximum levels within 60 minutes. Dose level and frequency of intake determine the steady state level of fluoride in plasma.

Excretion of Fluorides

Excretion by the gut and sweat glands

Fluorides are excreted through the kidney, the gut and the skin. Fluorides have low solubility and therefore, low absorption is excreted via the gut. Sweat and insensible perspiration may account for an appreciable loss of fluorine from the body. The concentration of fluoride in sweat is in the range of 0.067–0.5 ppm under normal conditions of intake.

Renal Clearance of Fluoride

The normal kidney will efficiently eliminate about 50% of fluoride, which is presented to it by glomerular filtration. It does not have access to all the fluoride to which an individual has been exposed.

Fluoride in Osseous Tissue

Fluoride ions have an affinity for skeletal mineral and can be incorporated in it during growth of the skeleton. Even in the absence of growth, it is ultimately incorporated by replacement of hydroxyl ions in the mineral of bone, hydroxyapatite.

Fluoride concentrations in bone tissue depend upon the amount of fluoride ingested in food and water, and to a lesser extent, the amount inhaled in air and on the length of time the individual has ingested fluoride. The fluoride can be deposited in either the (1) adsorbed layer of the bone (2) crystal structure (3) possibly bone matrix. The amount of fluoride that is not stored in bone is rapidly excreted through kidneys.

Distribution and Deposition of Fluoride in NonOsseous Tissues

Fluoride in blood is rapidly transferred, at rates of 30–40 %/minute to the extracellular fluid component. Approximately 96% of the fluoride retained in the animal body are found in bones and teeth, leaving a small quantity in soft tissues. Fluoride is a bone seeker and accumulates in other tissues that contain calcium. The ingestion of water containing negligible concentration to 4.0 ppm fluoride does not result in the accumulation of fluoride in the

heart, liver, lung or spleen.

Fluoride Transfer by Placenta

The presence of fluoride in primary teeth that develop during the intrauterine phase and the rapid increase in fluoride level of fetal blood when medications containing fluoride are administered to pregnant women indicate that fluorides readily cross the placenta. The skeletal fluoride increases with fetal age in areas that have water supplies of 0.1, 0.5 and 1.0 ppm.