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EDITORIAL

The Diagnosis and Prevention of Fluorosis in Humans

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ABSTRACT

Chronic fluoride intoxication in the form of fluorosis is a worldwide health problem and endemic at least in 25 countries. The principal cause of fluorosis in humans is the prolonged exposure of fluoride through drinking of fluoridated water. However, industrial fluoride emission and fluoride containing foods are also potential sources of fluoride exposures for the genesis of fluorosis. As per guidelines of the World Health Organization (WHO) fluoride content in the drinking water should not be higher than 1.5 mg/L (ppm). Above this limit of fluoride in drinking water, it becomes toxic and injurious for human health and causes diverse deformities in teeth and bones. In humans, basically three forms of fluorosis namely dental, skeletal and non-skeletal fluorosis have been recognised. The diagnosis of fluoride intoxication (fluorosis) in humans is made on the basis of history, clinical or pathognomonic signs and testing of biological samples. The current status of endemic fluorosis could be assessed by estimation of fluoride in the blood serum and urine. The presence of dental mottling and calcification of interosseous membrane on a forearm radiograph may be helpful in the diagnosis of dental and skeletal fluorosis, respectively. For the prevention of fluorosis, fluoride free drinking water and food items, diet having ample amount of nutrients, general awakening in people and collective efforts are important and highly needed. This editorial will be useful for researchers and health workers in the diagnosis and prevention of fluorosis in humans, respectively.

INTRODUCTION

Fluoride is found in water, soil, air and foods with varying concentration. It may be due to geogenic processes and/or human activities. Intake of fluoride has both beneficial and negative effects in humans which are depending on fluoride concentration. The consumption of water having fluoride in the range of 0.5 to 1.0 ppm is beneficial and reduces the possibility and incidence of dental caries but its excessive intake (fluoride >1.5 ppm) leads to genesis of osteo-dental fluorosis. At the global level, water-born fluorosis (hydrofluorosis) is the most common and widely spreads in humans [1]. But industrial fluorosis due to industrial fluoride exposure is restricted to the specific area or region [2]. Fluorosis is not restricted in humans [3-8] but also occurs in diverse species of wild and domestic animals [9-19].

Once fluoride enters the body it is absorbed by the digestive and/or respiratory systems and then ultimately reaches to all parts of the body through blood. More than 50% absorbed fluoride is excreted through stool, urine and perspiration, while rest is retained in the body where it accumulates in diverse organs. However, its maximum accumulation is found in calcified organs (bones and teeth) compared to non-calcified organs. This deference is due to availability of calcium. The bio-accumulation of fluoride causes diverse toxic effects or pathological changes and interference in various physiological and metabolic processes and ultimately triggers

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the genesis of adverse reversible and non-reversible health effects in people of all age groups. These fluoride induced toxic or health changes are collectively referred as fluorosis [1,2]. Various fluoride induced anomalies or deformities in teeth and bones are permanent, irreversible and untreatable and can be easily identified visually. But fluoride induced changes in soft tissues or organs are mostly reversible and disappeared when remove the source of fluoride exposure.

Chronic fluoride exposure through the ingestion of drinking water with a high fluoride level (>1.0 or 1.5 ppm) may cause the three forms of fluorosis, dental fluorosis or dental mottling, skeletal fluorosis or bone deformities and non-skeletal fluorosis [20]. All three forms may occur in the same individual.

DENTAL FLUOROSIS

This is the earliest visible clinical sign of chronic fluoride intoxication in humans which is sensitive, indexive and rampant in fluoride endemic areas. Clinically, this is characterised by diffuse hypocalcification which is generally appeared in the form of bilateral, striated and horizontal opaque light to deep brownish pigmented streaks on teeth surface. These pigmented streaks are relatively more contrast in appearance and sharply visualized on anterior teeth /incisors in children and adolescents as compared to old subjects (Figure 1A). Dental fluorosis may also be seen in the form of white or light to deep brownish spots, patches and fine dots or granules on the enamel of teeth. In its severe form, pronounced loss of the tooth-supporting alveolar bone occurs with recession and swelling of the gingival tissues and excessive abrasion or irregular wearing of the teeth [20].

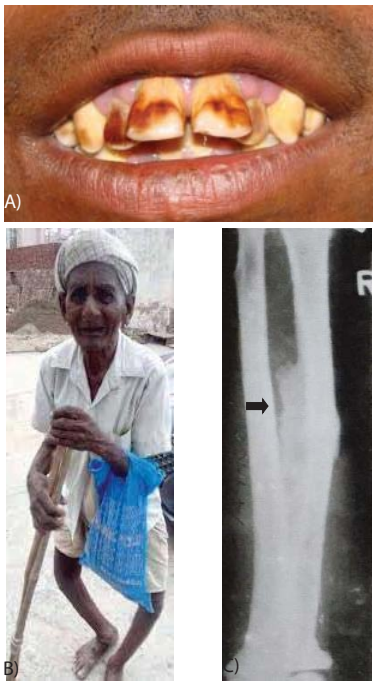

Figure 1 Dental fluorosis in adolescent subject (Figure 1A), severe skeletal fluorosis in old subject having crippling and genu-varum (legs bowed outward at the knee) deformities (Figure 1B) and radiograph of fore arm showing calcification of interosseous membrane (indicated by horizontal arrow) between radius and ulna bones (Figure 1C) indicating severe form of skeletal fluorosis.

SKELETAL FLUOROSIS

Excessive fluoride intake alters the equilibrium between formation and resorption of bones. This physiological process is accomplished by involvement of certain regulatory determinants and signalling pathways, thereby leading to various bone deformities known as skeletal fluorosis. This entity of chronic fluoride intoxication is very painful and more dangerous than dental fluorosis and is highly significant since it diminishes the mobility at a very early age by producing gradually varying changes in bones such as periosteal exostosis, osteosclerosis, osteoporosis and osteophytosis [21,22]. These changes appear clinically in the form of vague aches and pains in the body and joints. The excess accumulation of fluoride in muscles also diminishes the movements and the condition leads to crippling (Figure 1B). In its advanced stage, neurological complications such as paraplegia and quadriplegia and the syndromes of genu-valgum and genu-varum are also the resultant of regular fluoride exposure and this is the worst state of skeletal fluorosis.

NON-SKELETAL FLUOROSIS

This is the initial stage of chronic fluoride poisoning in humans exposed to fluoride. The diverse fluoride induced toxic effects in soft organs are gastrointestinal discomforts (intermittent diarrhoea or constipation, abdominal pain, flatulence etc.), urticaria, frequent tendency to urinate (polyurea), excessive thirst (polydipsia), neurological disorders, impaired endocrine and reproductive functions, teratogenic effects, renal effects, genotoxic effects, apoptosis, excitotoxicity, asthma, genital pruritus, lethargy, muscle weakness, bronchitis with violent cough, nasal irritation, irregular reproductive cycles, abortion and still birth [20]. These are the earlier signs of chronic fluoride toxicosis in people of fluoride endemic areas. But these are temporary and can be reverse in few days after removal of source of fluoride exposure. This is not necessary that all these fluoride induced health consequences are found at the same time in the subject.

The magnitude of fluorosis is depending on the several determinants besides the fluoride concentration in drinking water. The frequency and duration of fluoride intake are the major factors for the controlling of severity of chronic fluoride toxicosis. However, the age, sex, habits, nutrition, chemical constituents of drinking water, environmental factors, individual susceptibility, biological response, tolerance and genetics are also determinants of fluorosis [20,23-26]. Nevertheless, the magnitude of fluorosis is

relatively more depending on the density and rate of bio-accumulation of fluoride [27].

DIAGNOSIS OF FLUOROSIS

For the diagnosis of various forms of fluorosis requires basic knowledge of physiology of fluoride toxicosis, taking a relevant history, consciousness of the clinical features of the condition, proper physical examination and relevant investigations. In any area, whether there is chronic fluoride intoxication or fluorosis is endemic or not this can be determined by the presence of fluoride content in the biological samples, such as milk, urine, blood serum, nails, teeth, hair, sweat, bones, saliva, etc. as these are ideal biomarkers of fluoride toxicity. However, among these bio-samples, urine is the most ideal biomarker for the assessment of fluoride toxicosis because at the spot, it can be easily recollected noninvasively and systematically [27]. In fact, the level of fluoride in the urine gives the best indication of the presence of chronic fluoride poisoning and revealed its current status [20]. In the normal or healthy subjects, the normal range of fluoride ion in serum and urine is reported as 0.02-0.15 mg/L and 0.1-1.0 mg/L, respectively [28-30]. Fluorosis in any area and its intensity can also be predicted by the amount of fluoride in drinking water. Therefore, the estimation of fluoride level in drinking water is also useful and significant.

The diagnosis of dental fluorosis can be done by the examination of teeth in day hours (duration 9 a.m. to 3 p.m. is ideal) for the evidence of clinical signs. In fact, dental fluorosis is also a good biomarker for the evidence chronic fluoride poisoning. In general, children are ideal bio-indicators for chronic fluoride toxicosis as these are relatively more susceptible to fluoride toxicity and have low fluoride tolerance [27].

Based on increased bone density in various radiographs of bones, mild, moderate and severe forms of skeletal fluorosis can be identified or confirmed. Evidence of various pathognomonic signs such as chronic pain in joints, arthritic symptoms, calcification in vertebrae, joints and ligaments, crippling, muscle wasting, neurological deficits, etc. are also useful in the diagnosis of skeletal fluorosis. However, the calcification of interosseous membrane between radius and ulna bones (Figure 1C) is the most ideal and confirmative indication of skeletal fluorosis. Though, the diagnosis of non-skeletal fluorosis is difficult. However, it can be presumed by taking of history of subjects.

The history (gastrointestinal discomfort, loss of appetite, nausea, chronic constipation, intermittent diarrhoea, excessive thirst, frequent urination and chronic headache indicates, etc.), carefully physical examination and measuring of fluoride level in urine and serum are useful and important basic ways in diagnosis of chronic fluoride intoxication or fluorosis.

PREVENTION OF FLUOROSIS

Once fluoride induced deformities appeared in bones and teeth they are never reversible and untreatable. But, chronic fluoride intoxication (fluorosis) in people could be checked or controlled by adopting and implementation of the following possible ways: regular supplying or providing of fluoride free treated drinking water, checking the entry of fluoride in the body from sources of fluoride exposures or food items such as wine, tea, rock salt, tobacco and betel nut which are fluoride containing items, providing nutritious foods containing ample amount of calcium, vitamin C, vitamin E nutrients and antioxidants and awakening in people with the help of well-trained students and teachers towards preventive measures of chronic fluoride poisoning.

Regular supply of fluoride free drinking water at community level can be done by adopting a defluoridation technique. Though, several defluoridation techniques are available. However, the Nalgonda defluoridation technique is an ideal as it is simples, effective and low-cost which can be used. Although, this technique is affordable and gives good results but its success rate at the community level is poor due to lack of public participation, a lack of responsibility for its supervision and a lack of proper monitoring and maintenance. Instead of defluoridation technique, the harvesting and conserving of rainwater is a better option for regular obtaining low fluoride or fluoride free water. Regular supply of fluoride free water to the community from perennial freshwater reservoirs is also possible as these contained only traces of fluoride in their water [1]. Still, there is a need for collective efforts for fluorosis control, while monitoring and evaluation of fluorosis control projects also need to be done honestly.

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