

Fluoride Concentration

Abstract

In India, the clinical manifestations of fluorosis are reported at relatively low water fluoride levels which have harmful effects on teeth, bones and other systems of the body. The effects of fluoride on the teeth are related not to the beneficial properties of the fluoride, but to the detrimental effects of excessive levels present in most of the areas of India, on tooth development resulting into fluorosis or mottling of the teeth and bony deformities. A study was conducted on 130 subjects of 6 villages to be endemic for fluorosis. The study group included 70 adults and 60 children in whom dental examination and radiographs were taken. The features of osteomalacia like osteoporosis (3), triradiate pelvis (2) and growth arrest line (2) were reported. In children tooth mottling, leg deformities which included genu valgum (5), bowing of legs (3) and genu varum (1). The investigations in eight children were found rickets like osteoporosis (5), growth arrest line (4) and cupping of lower end of radius and ulna (one). There was raised serum alkaline phosphatase (237.6+107.6 U/L) coexisted with nutritional rickets or osteomalacia responsible by fluorosis.

Key Words

Hydroxyapatite, fluoridation, endemic fluorosis, osteosclerosis, osteomalacia, rickets.

Introduction

Endemic fluorosis in India has unique features of osteoarticular deformities like genu valgum and bowing of legs. Malnutrition which is common in India modify the clinical picture of fluorosis. This is mainly due to vitamin D deficiency which is required during the period of rapid growth. The dentistry for children changes greatly when water fluoridation and topical fluorides were used as a means of preventing dental caries. Scientists pointed out that fluorides strengthens teeth by reducing the tooth enamel's solubility against acids produced in the oral cavity by decomposition of carbohydrates present in the food. It does this by converting hydroxyapatite into the less soluble fluorapatite or by replacing the fluoride ions (F⁻) by the hydroxyl (OH⁻) ions during the apposition and calcification stage of crown formation. Other elements also can reduce the solubility of enamel such as lead, tin, copper and zinc.

This has been found by the studies that an optimum fluoride level of 1.0 ppm in water produces the maximum protection against caries with the least effect on any bony deformities and dental fluorosis. Fluoridation is most advantageous when

optimum quantities of fluoride are taken starting at birth and continues uninterrupted. Fluorides are found everywhere in nature, in the earth, water, air, plants and animals including humans. Fluorides thus become part of the earth's cycle - the ecosystem. In India, there are areas which have different levels of fluoride in the drinking water. Some areas are with naturally low levels, while others have high levels of fluoride in water. In India ground waters such as tubewells, hand pumps, open well, springs are the sources of fluorides. Fluorides usually occur in these sources, because of the presence of fluorspar, phosphate rocks, or cryolite. The fluorides in such waters are present because they have dissolved and the fluoride ion is freed from one or more of these three sources. A small proportion of fluoride is obtained from foods. Almost all foods contain some amount of fluorides. Most vegetables and meat contain less than 1.0 ppm fluoride on a dry basis. Tea, which is very much common in India contains as much as 60 ppm fluoride.

Observation

The problem with fluoride is that while small quantities of fluoride are good for

¹ Ram Kumar Srivastava

¹ Professor & Head
Department of Oral & Maxillofacial Surgery
Chandra Dental College & Hospital, U.P., India.

Address For Correspondence:

Dr. Ram Kumar Srivastava
Professor & Head
Department of Oral & Maxillofacial Surgery
Chandra Dental College & Hospital,
Barabanki, U.P., India.

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teeth and in treatment of some skeletal diseases, too much can harm the human being. It is a fact that fluoride should be supplemented within prescribed limits. The high levels of fluoride in water can give fluorosis of teeth, skeletal deformities, kidney diseases, eye and skin diseases. Thus, the population in areas of excess fluorine in drinking water over a period of time will suffer. Endemic fluorosis has emerged as one of the most alarming public health problems in most of the areas of various states of India. According to reports about one million people require immediate attention because they are consuming more than 1 ppm fluoride. In India, drinking water in most of the areas have 10 ppm or more fluoride content, which is injurious to health (Table I a & b).

The most endemically fluorosis affected districts in the various states of India are: Nalgonda, Guntur, Nellore in Andhra Pradesh, Batinda, Sirsa, Gurdaspur in Punjab; Jaunpur, Pali, Negaur districts in Rajasthan; Unnao and Pratapgarh districts in Uttar Pradesh (Table II a & b). These are the districts where water fluoride level is as high as 18 ppm against

the optimum level of 1 ppm. About every inhabitant of these districts is suffering from an advanced stage of skeletal fluorosis, which is more worse than the dental caries.

In Uttar Pradesh about 50% of population of the state gives evidence of fluorosis, either in the form of bone deformities or tooth mottling. 12 of the districts of the state are affected with fluorosis, containing water-fluoride level higher than 1 ppm. The most worst affected areas are Unnao and Pratapgarh, where about 90% of the population is affected by higher concentration of water-fluoride content. Children in these areas show evidence of bone deformities, eye and skin diseases, urinary problem, other than the tooth mottling, are more serious than the fluorosis of teeth, with no cure of their conditions. The following 12 districts of Uttar Pradesh show evidence of higher concentration of fluoride in water are Unnao, Pratapgarh, Mathura, Etawah, Allahabad, Fatehpur, Shahjahanpur, Etawah, Lucknow, Bahraich, Raibareli and Faizabad.

The sample collected in these districts is from various sources, even though they show evidence of higher fluoride content. These are Handpump (India Mark II), open well, tube well, tap water (municipal supply).

The most highly affected areas of Unnao (Table III) showing evidence of fluoride content more than 1 ppm are:

These villages are situated about 30 km from Lucknow. The sources of drinking water are hand pump, open well, tube well and tap water. A door to door survey was conducted, medical histories were taken and physical examinations were done according to fixed protocol. Tooth mottling was recorded on a I-III scale. Studies show that the two most highly significant clinical manifestations linked with fluoridation in the areas, which have high fluoride level than the presented limits of more than 1 ppm are tooth mottling (various levels from grade 0 to 4 according to Dean's classification from normal to severe forms of tooth mottling) and various forms of bone deformities.

Results

Sixty children (12 years and under) and 70 adults were studied. The mean age of the children was 7.5 years (range 3-12)

and mean age of the adults 33.9 years (range 13-70). The male female ratio was 2.4:1. In the adults, the symptoms and signs are more frequent and severe than the children (Table IVa & b).

Bone deformities involves leg deformities and osteosclerosis. Intake of fluoride from water in amounts of 8-20 mg/day for years can lead to increased density of bone with large doses, the changes may become crippling osteoporosis, may replace osteosclerosis after a long period, which is very common in children of these areas of Unnao of Uttar Pradesh. In the adults, pain and stiffness of joints (20), tingling and numbness in feet and hands (4) and weakness (3) were reported. The physical signs included tooth mottling (10 of grade I, 15 of grade II and 42 of grade III). 8 cases of stooping posture, 4 of bony out growths, at the upper end of tibia, metatarsal bone and on the spinous process of thoracic vertebra resembling exostosis, 3 of generalized hyperreflexia of tendon jerks and 1 of radiculopathy of right sixth cervical root. In the children tooth mottling grade I affected 22, grade II, 20 and grade III 12. The leg deformities included 5 cases of genu varum and 3 of bowing of legs, 4 growth arrest line.

Other disorders most frequently linked with fluoridation in these areas are: Gastrointestinal irritation such as nausea, vomiting, cramping pain and diarrhea, convulsions, hypoglycemia and hypocalcemia, malabsorption, allergies, disorders of eye such as conjunctivitis, respiratory disease such as asthma, bronchitis.

Biochemical Features

Serum calcium and phosphorus levels in the adults were 9.39+1.38 mg% and 4.1+0.82 mg% in children 9.87+1.39 mg% and 4.08+0.85 mg% respectively. These values were normal but alkaline phosphatase levels were raised. Alkaline phosphatase was 229.70+123.08 U/L in adults and 287.68+48.96 U/L in children.

Discussion

Fluorosis is endemic in these villages of Unnao. Ninety three percent of the cases had varying degree of tooth mottling. Twenty out of 21 adults, whose radiographs were taken had osteosclerosis or membrane calcification. In 3 cases features of

osteomalasia-triradiate pelvis and growth arrest lines were present. In the children the only evidence of fluorosis was tooth mottling. Seven out of 8 children whose radiographs were taken had radiological features of rickets.

Our studies have evidence that fluorosis is endemic in most of the areas of India due to high fluoride level in water regardless of sources of water, may be open well, hand pump, tube well or municipal water supply. This may be due to presence of fluorspar, phosphate rocks or cryolite resulting into high fluoride concentration in the water supply. According to the survey other factors responsible for fluorosis are high.

Temperature conditions in various parts of India require consumption of more water than inhabitants of cold climatic conditions resulting in high fluoride intake than the optimum requirement per day. We know that fluoride is a requirement for body as a trace element and large number of food supplement can give such a small amount by maintaining dietary habits and it is not necessary to give the community large doses of fluoride by fluoridation of water.

The other factor may be non-coordination between the Public Health Department, Geological Survey of India, dental surgeons, pediatricians, orthopedic surgeons and laboratory technicians to supervise and control level of fluoride in water not more than the optimum level.

Nutritional deficiency which is very much common in India, responsible for deformities associated with fluorosis.

By the various studies this has been proved that fluoride has an effect to prevent caries but due to high intake of fluoride by the population of India, it can lead to various non-dental systemic diseases, which is more dangerous than the dental caries. These serious conditions especially bone deformities, renal diseases and disorders of eye are permanent and have no cure.

The community should not be fluoridated as a free choice for accepting medication without proper accessing the areas about the level of fluoride in water, whether it is in the form of tooth paste or fluoridation of water. Care should be exercised in

prescribing fluoride tooth paste in areas containing excessive natural fluoride in the water supply because of possible excessive fluoride intake, particularly among children who might consume it, resulting into bony and other systemic diseases.

The fluoridation in water is only safe procedure at the recommended levels where it has been established that the fluoride content of water is below 1 ppm and it is not recommended in areas containing natural fluoride more than the 1 ppm in water.

By Hodge & Smith, they concluded that 5-10 gm of sodium fluoride would be fatal for a person with a body weight of 70 kg. Sodium fluoride is 45.2% fluoride by weight, the dose range for adults would be 32-64 mg F/kg. For a child the fluoride dose ingests in excess of 5 mg F/kg result in death.

Conclusion

Fluoride is a toxic substance. Its acute ingestion in large quantities may be followed by rapidly developing signs and symptoms, which may result in dental, skeletal and systemic diseases. When it is ingested in relatively small amounts during the period of tooth development (especially enamel matrix formation and mineralization), it may produce changes in the enamel. When large amounts are ingested over a period of years, changes in skeleton may occur. In India the clinical and radiological changes appear at relatively low water fluoride levels as compared to Western countries. This may be due to malnutrition, which is common in India. The effect of vitamin D deficiency may manifest especially in children because of increased requirement of nutrients during the period of growth. The dietary deficiency of vitamin D suggests that nutritional osteomalacia and rickets coexisted with fluorosis in our study. In India, from other areas of Andhra Pradesh, the radiological changes consistent with rickets, osteoporosis and hyperparathyroidism have been reported with fluorosis in children.

Fluoride produces metabolic changes in bone by enhancing both osteoclastic and osteoblastic activities. Osteoclastic activity leads to osteoporosis and the osteoblastic activity leads to osteosclerosis and rickets.

The studies show that these disorders of bone which is more common in fluoride rich natural water sources are the result of insufficient mineralization of a normal organic matrix due to reduced absorption of calcium from the gut by high fluoride intake or due to a calcium deficient diet or lack of vitamin D. This means that ingestion of high amount of fluoride can result in the malformation of bone. The rickets in children and osteomalacia in adults are seen in areas where the drinking water contains more than 1 ppm fluoride. Ingestion of excess fluoride affects the solubility and therefore the reactivity of bone apatite crystals by substitution of F for OH by increasing the bone crystal size. Infact, bone crystals are of the order of size where a slight increase in crystal size due to fluoride will decrease the solubility of bone mineral resulting in decrease in the bone resorption induced by parathyroid hormone. The fluorosis reveals signs of osteosclerosis with a thickened skeleton due to appositionally formed bony tissue, spur formations and ossification of ligaments.

In India, where most of the areas contain fluoride more than the prescribed limits, the following recommendations should be followed:

1. To prevent the caries the fluoride should be applied in the form of solutions only by dental professionals.
2. This should be applied to children with supervision. The patient, who are under fluoride solution treatment should not be left unattended.
3. Fluoride tooth paste should not be prescribed as a general tooth paste for the population without assessing the water-fluoride content.
4. Government should plan to reduce the problem of malnutrition in children.
5. Water fluoridation for the prevention

of caries is not an appropriate means in India because of the risk of developing toxic effects in most of the areas.

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