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FURTHER OBSERVATIONS ON ENDEMIC FLUORIDE-INDUCED OSTEOPATHIES IN CHILDREN

by

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SUMMARY: Fluoro-osteopathy has been described in four children aged 6 or above. These observations contrast with the concept that skeletal fluorosis cannot develop prior to 10 to 20 years of high fluoride intake. The pathogenesis and the mechanism underlying the causation of this disease is discussed on the basis of the occurrence of skeletal fluorosis in growing children. Since skeletal fluorosis is a preventable disorder, it is important to either recognize it or consider it in the differential diagnosis of each bone and joint disease in a child residing in an endemic area.

In spite of the common occurrence of dental fluorosis in children residing in endemic fluoride areas, no attempt has been made to investigate the incidence and severity of skeletal fluorosis in these cases. All reports are confined to studies in adults. The only published data is that by Teotia et al. (1) who described endemic skeletal fluorosis in three children ranging in age from 11-13 years. One of the three cases had crippling fluorosis which improved markedly on allow calcium diet. In the current communication, the authors present further observations on endemic fluorosis in children.

Materials and Methods

Because of practical difficulties, random investigations were undertaken of only those children willing to be examined in the hospital. All 16 children (11 male and 5 female) between 6 and 15 years of age were subjected to investigations for establishing the diagnosis of skeletal fluorosis. All belonged to the poor socio-economic strata and had been residing since birth in an endemic fluorosis area, in the district of Rai Bareli, Uttar Pradesh, India. For the survey all cases were given X-rays of the skeleton, particularly of the spine, pelvis and bones of the forearms.

Laboratory investigations included serum calcium, serum phosphorus, serum magnesium, alkaline phosphatase, blood urea, creatinine clearance, chemical analysis of bone ash for calcium, phosphorus, magnesium and fluoride. Histological studies of undecalcified and decalcified sections of the biopsied iliac crest bone were done. The fluoride content of the bone, drinking water and urine samples was measured spectrophotometrically, with the use

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of the zirconium dye complex as detailed by Megregian (2).

Observations and Results

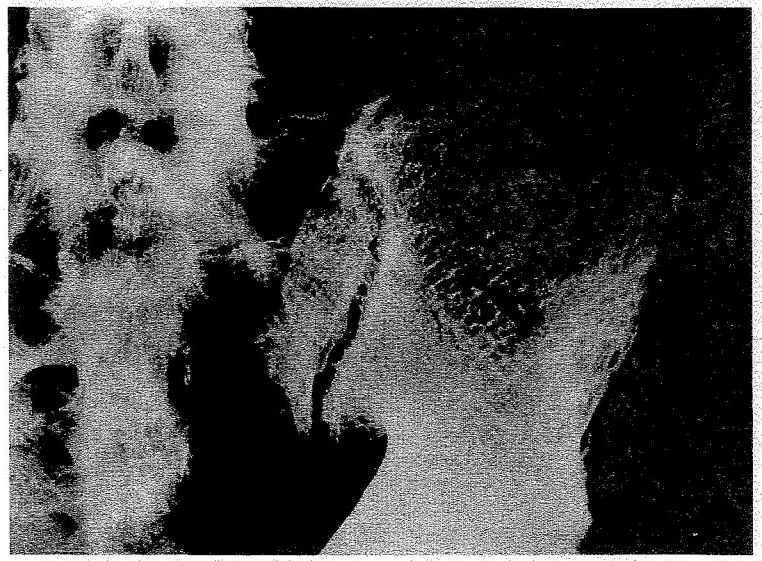
The results of the study are presented in Tables 1 to 4 and Figures 1 to 6.

Skeletal Radiographs

The radiological changes were those of a diffuse increase in density of most of the skeleton, particularly the spine, pelvis and thorax with coarse trabeculations in the knees and elbows (Fig. 1). Two patients showed

Fig. 1

Pelvic Radiograph Showing Osteosclerosis, Coarse Cystic Trabeculations



calcification of the interosseous membrane of the forearms (Fig. 2) and excessive and irregular deposition of bone around the foramen magnum (Fig. 3). Dental radiographs revealed thinning and interruption of the lamina dura in one child.

Histopathological Data

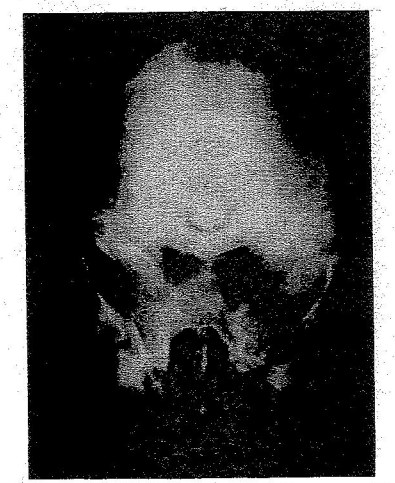
Histology of the undecalcified sections of the bone obtained from the

Fig. 2

Radiograph Showing Calcification of Interosseous Membrane of the Forearms as a Diagnostic Feature

Fig. 3

X-Ray of the Skull



Marked Sclerosis of the Bone Around Foramen Magnum

Fig. 4

Histopathological Picture of Iliac Crest Bone Biopsy (Undecalcified)

Showing markedly thickened trabeculae containing excess calcium.

Fig. 5

Histopathological Picture of the Iliac Crest Bone Biopsy (Decalcified)

Poorly formed Haversian Systems, disordered lamellar orientation and absence of nuclei in some of the osteocyte lacunae, suggesting impaired viability of bone.

iliac crest by open biopsy showed thick trabeculae which contained an excess of calcium (Fig. 4). Decalcified sections revealed poorly formed Haversian system, disordered lamellar orientation of the compact bone and absence of nuclei in some of the osteocyte lacunae (Fig. 5).

Fluoride in Water Supply

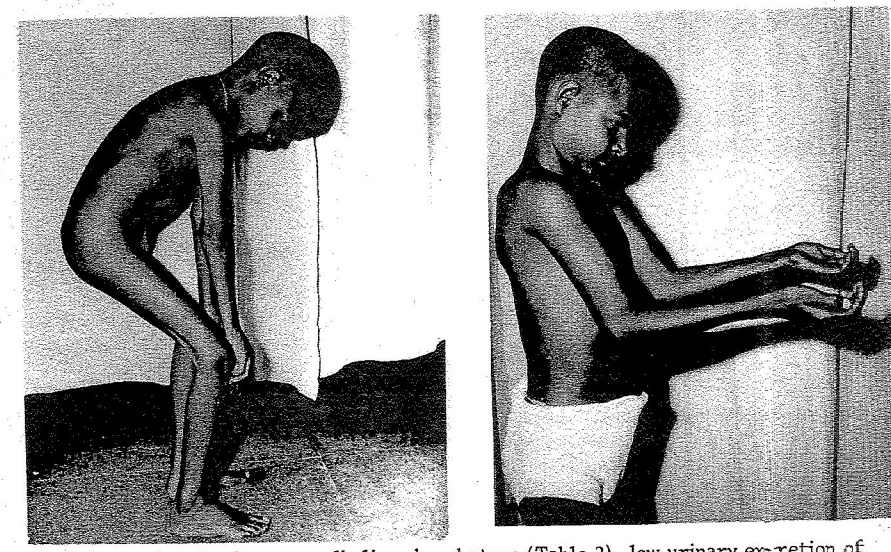
Twenty samples of drinking water were analyzed from four wells located at different places in the endemic area. They contained 10.35 to 13.5 ppm of fluoride.

All children were symptomatic (Table 1). The usual clinical features were generalized stiffness, back pain, inability to close the fist and flexion deformities of spine and joints (Fig. 6). Laboratory investigations

Fig. 6

A Child With Endemic Skeletal Fluorosis Showing Flexion Deformity of the Cervical Spine and Inability to Close the Fists

Before After



showed a rise in serum alkaline phosphatase (Table 2), low urinary excretion of calcium, increased urinary excretion of phosphorus and fluoride with retention of calcium in each patient (Table 3). The usual radiological changes were those of osteosclerosis, namely periosteal bone formation and ossification of the in-

TABLE 1

SYMPTOMATOLOGY IN FOUR CHILDREN WITH SKELETAL FLUOROSIS

Case No.	Sex	Age (Yrs)	Duration of symptoms	Walking	Skeletal pain and tenderness	Spine	Joints	Muscular	Gastro-intestinal	Chest	Mottled discoloration of teeth
1	M	14	11	-	-	Stiffness Cervical flexion	Pains	Inability to close fists	Constipation	-	Brown
*2	M	6	2	Difficulty	-	Backache Stiffness	Pains Bowing of legs	Inability to close fists	Constipation	-	Yellowish brown
3	F	15	4½	Inability	Severe	Backache Stiffness Thoracic kyphosis	Pains Stiffness Flexion at knees	Inability to close fists	Constipation	Fixation of chest	Brown
4	M	11	2	Limping	-	Stiffness Cervical flexion	Stiffness Painful movements	Inability to close fists	-	-	Yellowish brown

*Patient had associated Rickets.

TABLE 2

LABORATORY INVESTIGATIONS IN PATIENTS STUDIED

Patient No.	SERUM				Fluoride in drinking water (ppm)
	Calcium* (mg%)	Phosphorus (mg%)	Alkaline Phosphatase (K. A. Units)	Magnesium (mEq/Lit)	
1	10.0	4.3	32	2.0	10.4 - 13.5
2	9.8	3.5	25	1.90	
3	10.2	3.8	37	2.1	
4**	10.8	3.0	55	1.80	

*Normal Ca 9.0 - 11.0 mg/100 ml.

**Radiological findings suggested hyperparathyroidism presumably secondary to the fluorosis.

TABLE 3

Calcium Balances (In Six Day Period) and Urinary Fluoride Excretion in Four Children With Skeletal Fluorosis

Case No.	Calcium intake (mg/day)	Urine calcium (mg/day)	Faecal calcium (mg/day)	Calcium balance (mg/day)	Urine fluoride (ppm/day)
1	860	28	590	+242	3.5
2	890	15	620	+235	2.4
3	860	40	495	+325	3.8
4	860	60	560	+240	3.0

terosseous membrane. The roughening and accentuation of muscular and ligamentous attachments, particularly of the ischial spine and iliac crests may be present before the development of osteosclerosis. Histological studies of the undecalcified sections of the iliac crest biopsies showed thick and hypercalcified bone trabeculae. The decalcified sections revealed disordered lamellar orientation and absence of nuclei in some of the osteocyte lacunae, suggestive of impaired viability of bone. The excess content of calcium, fluoride and magnesium in the bone ash indicated a close relationship between bone apatite crystal and the composition of the fluids (blood serum) in which crystal formation takes place (Table 4).

TABLE 4

Chemical Composition of Bone Obtained from the Iliac Crest of the Patients Studied (Per 100 g Dry Fat Free Bone)

Case No.	Calcium (g)	Phosphorus (g)	Magnesium (g)	Fluoride (g)
*Normal Patients	11.0	5.05	105	28.5
1	12.5	5.2	110	472
2	11.4	4.9	106	325
3	12.2	5.8	112	280
4	11.6	5.0	105	285

*Persons from non-fluoride area.

Discussion

Our study does not support the published reports that for a definite picture of skeletal fluorosis to develop, 10 to 40 years' residence in an endemic area is necessary. In our opinion, growing children with active bone metabolism, if exposed to high fluoride intake, are more prone to develop skeletal fluorosis than adults. As bone ages and becomes more or less stabilized in the remodelling of its Haversian systems, less fluoride may be deposited. We observed that individuals residing in an endemic area since birth develop more severe skeletal fluorosis than those who have moved into the endemic zone after 17 to 18 years of age when bone growth has ceased.

Our results further indicate that fluoride is not deposited uniformly throughout the skeleton. It may be related to the rate of growth, the degree of vascularization and the physical stress in various parts of the same bone. More fluoride is deposited in the epiphyseal line, and in the epiphyses than in the diaphyseal portion of the bone. A similar observation has been reported by Zipkin and Scow (3). Thus fluoride appears to have an affinity for deposition at the sites of active physiological calcifications. The increase in the percentage of fluoride, like that of calcium in the skeleton, occurs progressively during growth. Apposition of new bone on the trabecular surfaces probably accounts for the increase of density radiologically.

On the basis of our work we recommend that all children residing in an endemic zone regardless of whether symptoms or dental mottling are manifested should be screened for skeletal disease, because early diagnosis will help to prevent the crippling stage of the disease.

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URINARY FLUORIDE ELIMINATION AND FLUORIDE DEPOSITION IN BONES AND TEETH OF THE RATS AFTER INHALATION

by

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SUMMARY: Rats in the experiment inhaled fluoride in concentrations 9.4 - 11.7 µg per liter of air for a period of five months. The animals were divided into four groups, three exposed and one control. The first experimental group was exposed 90 hours, the second 180 and the third 270 to hydrogen fluoride in the inhalation chamber.

After inhalation of 9.4 - 11.7 µg F/l of air, rapid absorption of fluoride in the organism took place. This was indicated by increased elimination of fluorides in the urine, the occurrence of the characteristic changes in the dental enamel and elevation of fluoride in bones and teeth, without radiographic changes. The changes following administration of fluoride by inhalation are the same as those due to oral administration. Fluoride absorbed by the lung was eliminated rapidly from the organism; the amount present in the urine depended upon the duration of exposure. About one third of inhaled fluoride was eliminated in the urine. Fluoride deposition in bones and teeth increases regardless of the duration of intoxication. No increase in fragility of bones was noted in relation to their fluoride content

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