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ENDEMIC FLUOROSIS IN SOUTHERN RAJASTHAN, INDIA

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SUMMARY: Chronic fluoride intoxication in the form of osteo-dental fluorosis was investigated in 21 villages of Banswara, Dungarpur, and Udaipur districts of southern Rajasthan, where fluoride (F) concentrations in drinking waters range from 1.5 to 4.0 ppm. Interestingly, a variable prevalence of fluorosis was observed in villages having almost the same F concentrations. At 1.5 ppm, 21.3, 25.6, and 38.9% of children and 33.3, 36.9, and 44.8% of adults in different villages of these districts were found to be affected with dental fluorosis. The maximum prevalence of dental fluorosis (77.1%) was found in the 17-22 year age group. No significant correlation was found between prevalence figures and gender. At this 1.5 ppm F concentration, 6.1, 6.8, and 9.5% of adults in villages of Banswara, Udaipur, and Dungarpur districts, respectively, showed evidence of skeletal fluorosis. Subjects of these districts showed the highest prevalence of skeletal fluorosis, 32.8, 36.6, and 39.2% at maximum F level of 3.7 ppm, 4.0 ppm, and 3.2 ppm, respectively.

No children were found affected with skeletal fluorosis or skeletal deformities, the prevalence of which was higher in males and increased with age and higher F level. Deformities such as crippling, kyphosis, and genu varum were observed most frequently in higher age groups (>40 years) at a F concentration of 2.8 ppm or higher. None of the fluorotic subjects showed evidence of goitre (thyroidism) or genu valgum syndrome. Radiological findings of other deformities in fluorotic subjects were also found. Possible factors responsible for a higher prevalence of fluorosis in villages having similar F concentrations are discussed.

Keywords: Fluoride intoxication, Dental fluorosis, Skeletal fluorosis, Southern Rajasthan.

INTRODUCTION

Chronic fluoride intoxication (fluorosis) is a worldwide health problem and is endemic in areas where F content is high in drinking waters. The primary manifestations of fluorosis are mottling of teeth and osteosclerosis of the skeleton; secondary effects include damage to the nervous system in humans and animals. In India, fluorosis is endemic in many states.[1,2] In the state of Rajasthan, almost all districts have high F (up to 18.0 ppm) in their drinking/ground water sources.[3] In southern Rajasthan, where tribal populations are predominant, 0.3 to 10.8 ppm F concentration is reported.[4-7]

Fluorosis has been reported form other parts of Rajasthan,[8-17] but only in a few districts. Therefore, the present study was undertaken to determine the relative prevalence of fluorosis in those villages having almost the same fluoride levels in their drinking/ground water sources of three districts of southern Rajasthan: Banswara, Dungarpur, and Udaipur. Radiological examinations for other skeletal deformities in fluorotic subjects as well as inspections for thyroidism (goitre) were also carried out.

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MATERIALS AND METHODS

Data were collected as reported earlier[5] in those villages of the above-named districts of southern Rajasthan having similar F concentrations (range 1.5 to 4.0 ppm) in their drinking waters and pH, total hardness, and total alkalinity within the permissible limits. A cross-sectional survey was used to determine the prevalence of fluorosis. Teeth of children and adults of both sexes, were examined for evidence of dental fluorosis, using grade II mottling as a criterion.[18] For skeletal fluorosis, adults over the age of 21 who had lived in one of the villages for more than 15 years were included in the study and were examined clinically as described elsewhere.[2-11] In addition, 2-3 clinically identified fluorotic subjects (>30years) from each village were also examined radiologically for further evidence of skeletal fluorosis or other skeletal changes. Fluorotic subjects were also examined for evidence of generalized swelling of the thyroid gland (goitre).

Fluoride concentration in urine or blood plasma and T_3/T_4 in serum were not estimated in the fluorotic subjects in the present study. Data on fluorosis were based on clinical findings only.

RESULTS AND DISCUSSION

Dental Fluorosis: Grade II or higher dental fluorosis (Figures 1-6) was found in 653 of 1571 children (41.6%) and in 1119 of 2303 adults (48.6%), giving an overall prevalence of 45.7% in the present study areas (Table 1). A variable prevalence of dental fluorosis was observed in those villages of Banswara, Dungarpur, and Udaipur districts having almost the same F levels in their drinking water. At 1.5 ppm F, the villages of these districts showed 30.4, 42.4, and 29.4% overall prevalence of dental fluorosis, respectively. The maximum prevalence (77.1%) of dental fluorosis was observed in the 17-22 year age group and the minimum (58.6%) in the 5-10 year age. However, little variation was found between the prevalence figures of the sexes.

At 2.6 ppm F, most children and adults showed evidence of a further stage of dental fluorosis (corrosion of tooth material with deep brown or black staining). In older people, posterior teeth revealed maximum corrosion, while anterior teeth showed diffused type of dental fluorosis (Figure 7). In general, the prevalence of dental fluorosis was higher in Dungarpur district and increased with the amount of fluoride in the water (Table 1). Statistically, the degree of correlation between F concentration and prevalence of dental fluorosis in both children ($r = +0.8513$) and adults ($r = +0.7500$) was found to be positive.

In India, dental fluorosis has previously been described in humans ingesting 0.5 to 1.0 ppm F in drinking water,[19,20] while at concentrations of 3.4 to 3.8 ppm, 100% dental fluorosis has been reported.[11,21] In the present study, the highest overall prevalence of dental fluorosis (63.4% in Banswara, 77.2% in Dungarpur, and 72.5% in Udaipur district) was observed in villages with

3.7 ppm, 3.2 ppm, and 4.0 ppm F concentration, respectively. Thus the occurrence of fluorosis can vary widely among different locations having almost the same F concentrations in the drinking water and can be affected by a number of other factors such as nutritional status, climate, individual susceptibility and biological response, duration of F exposure, and dissolved salts in drinking waters. But besides these factors, the difference in the prevalence of fluorosis in the villages having almost the same F levels appears to be due mostly to differences in the "frequency of fluoride intake". In the villages of Dungarpur district, for example, almost all the ground and surface water sources contain considerable F, whereas in Banswara and Udaipur districts only ground waters contain appreciable amounts of F.[6] Therefore, chances of higher fluoride intake are greater in Dungarpur district, and a high prevalence of fluorosis in the villages of this district is more likely.

Figures 1-7. Different forms of dental fluorosis seen in children and adults

Table 1. Prevalence (%) of dental and skeletal fluorosis

Districts and villages	F Concentration (ppm) Mean	Range	Dental fluorosis (DF) Children (<16 yrs)	Adults (>21 Yr.)	Total	Skeletal fluorosis Adults (>21 yrs.)	Crippling fluorosis
Banswara							
Deoliya	1.5	1.6 - 2.8	21/82 (25.6)	44/132 (33.3)	65/214 (30.4)	8/132 (6.1)	-ve
Isarwada	1.6	1.2 - 2.1	14/68 (20.6)	27/108 (25.0)	41/176 (23.3)	7/108 (6.5)	-ve
Gangertalai	1.9	1.2 - 3.0	21/77 (27.3)	30/102 (29.4)	51/179 (28.5)	15/102 (14.7)	-ve
Vassioda	2.6	2.2 - 2.9	25/80 (31.2)	44/122 (36.1)	69/202 (34.2)	23/122 (18.9)	-ve
Mangala	3.3	2.7 - 4.1	26/64 (40.6)	57/126 (45.2)	83/190 (43.7)	31/126 (24.6)	+ve
Borda	3.5	2.6 - 4.2	31/64 (48.4)	61/120 (50.8)	92/184 (50.0)	36/120 (30.0)	+ve
Chhotipadel	3.7	2.9 - 4.6	52/86 (60.5)	76/116 (65.5)	128/202 (63.4)	38/116 (32.8)	+ve
			190/521 (36.5)	*339/826 (41.0)*	*529/1347 (39.3)*	*158/826 (19.1)*	
Dungarpur							
Fatehpura	1.5	1.6 - 2.3	28/72 (38.9)	47/105 (44.8)	75/177 (42.4)	10/105 (9.5)	-ve
Mewadi	1.6	1.1 - 1.8	23/88 (26.1)	34/112 (30.4)	57/200 (28.5)	10/112 (8.9)	-ve
Jhariyana	1.8	1.7 - 2.0	37/92 (40.2)	49/104 (47.1)	86/196 (43.9)	20/104 (19.2)	-ve
Indora	2.4	1.1 - 3.1	34/78 (43.6)	55/105 (52.4)	89/183 (48.6)	27/105 (25.7)	-ve
Deotalab	2.8	1.5 - 4.1	34/63 (54.0)	49/98 (50.0)	83/161 (51.6)	39/98 (39.8)	+ve
Dad	3.1	2.8 - 3.9	37/58 (63.8)	69/96 (71.9)	106/154 (68.8)	41/96 (42.7)	+ve
Bokedsal	3.2	2.9 - 3.5	38/56 (67.9)	84/102 (82.4)	122/158 (77.2)	40/102 (39.2)	+ve
			231/507 (45.6)	*387/722 (53.6)*	*618/1229 (50.3)*	*187/722 (25.9)*	
Udaipur							
Matasula	1.5	1.2 - 1.7	20/94 (21.3)	38/103 (36.9)	58/197 (29.4)	7/103 (6.8)	-ve
Amlu	1.6	1.3 - 1.6	15/76 (19.7)	35/94 (37.2)	50/170 (29.4)	8/94 (8.5)	-ve
Dagar	1.9	0.2 - 3.0	25/78 (32.1)	36/90 (40.0)	61/168 (36.3)	14/90 (15.6)	-ve
Thada	2.6	0.2 - 5.1	25/65 (38.5)	42/102 (41.2)	67/167 (40.1)	20/102 (19.6)	-ve
Bhabrana	3.0	2.6 - 3.5	28/60 (46.7)	56/114 (49.1)	84/174 (48.3)	24/114 (21.1)	+ve
Dhamodar	3.8	3.0 - 4.7	51/72 (70.8)	80/110 (72.7)	131/182 (72.0)	37/110 (33.6)	+ve
Jhalara	4.0	3.5 - 4.7	68/98 (69.4)	106/142 (74.6)	174/240 (72.5)	52/142 (36.6)	+ve
			232/543 (42.7)	*393/755 (52.1)*	*625/1298 (48.2)*	*162/755 (21.5)*	
Total			*653/1571 (41.6)*	*1119/2303 (48.6)*	*1772/3874 (45.7)*	*507/2303 (22.0)*	

F, Fluoride, Correlation coefficient between: (1) F concentration and DF in children, r = +0.8513 (positive correlation);
(2) F concentration and DF in adults, r = +0.7500 (positive correlation); (3) F concentration and SF in adults, r = +0.8623 (positive correlation).

Skeletal Fluorosis: Evidence of skeletal fluorosis of varying grades was noted in 267 of 1166 adult males (22.9%) and in 240 of 1137 adult females (21.1%), giving an overall prevalence of 22.0% (Table 2). None of the children were found to have skeletal fluorosis or skeletal deformities. At 3.2 ppm, 3.7 ppm, and 4.0 ppm F concentration in the villages of Dungarpur, Banswara, and Udaipur districts, the highest prevalence of skeletal fluorosis was 39.2, 32.8, and 36.6%, respectively. The prevalence of skeletal fluorosis at different F levels in all the villages studied is shown in Table 1. Onset of skeletal fluorosis at 1.5 ppm F was observed only in the higher age group (>40 years). Crippling fluorosis was found at and above 2.8 ppm F. The more extreme forms of skeletal fluorosis – kyphosis and genu varum (Figures 8-11) were observed only in adults over the age of 45 who had drunk water containing 3.2 ppm F. Secondary neurological complications, paraplegia, and quadriplegia (Figures 12-14) were only seen in few adults (>50 years) drinking water with 4.0 ppm. None of the fluorotic subjects showed evidence of genu valgum deformity or generalised swelling of the thyroid gland (goitre).

Table 2. Skeletal fluorosis (SF) in relation to age and sex

Age (years)	Males examined	Positive SF (%)	Females examined	Positive SF (%)	Total SF cases
21-30	280	32 (11.4)	278	27 (9.7)	59/558
31-40	294	38 (12.9)	290	36 (12.4)	74/584
41-50	265	60 (22.6)	258	52 (20.2)	112/523
51-60	178	63 (35.4)	166	56 (35.7)	119/344
>60	149	74 (49.7)	145	69 (47.6)	143/294
21 to >60	1166	267 (22.9)	1137	240 (21.1)	507/2303 (22.0%)

Figures in parenthesis indicate percentage. Correlation coefficient between age and SF in both sexes, r = +1.000 (highly positive correlation).

Several workers have reported skeletal and crippling fluorosis at F levels above 1 ppm and 3 ppm, respectively.[18] Moreover, other deformities have also been observed in endemic areas of fluorosis. In the present study, no cases of goitre or genu valgum were noted, in contrast to some of the southern (Andhra Pradesh, Karnataka, and Tamil Nadu) and middle (Madhya Pradesh) Indian states where fluorosis is also endemic and cases of genu valgum along with osteoporosis of long bones have been reported.[22-24] The way in which F causes these deformities is still uncertain and inconclusive. The relationship between F intoxication and thyroid function is poorly understood and highly debatable. In India, some workers have reported no goitre incidence,[1,12,25] while others observed it in endemic fluorosis areas.[26]

The prevalence of skeletal fluorosis also increased with increasing F concentration and age (Tables 1 and 2), and was higher in males (Table 2). Statistically, positive correlations were found between F concentration and skeletal fluorosis (r = +0.8623), and age and both sexes (r = +1.000).

The proportion of males affected by fluorosis was slightly but significantly higher than the proportion of females. One possible explanation might be that men drink more water than women to compensate for fluid loss during field work. They also drink more wine and tea, both of which can increase fluoride intake. The smaller proportion of women with fluorosis may also result, in part, from an influx of women into the villages on marriage, from areas

Figures 8-11. Cases of skeletal fluorosis showing common deformities: kyphosis, genu varum, and crippling

where fluorosis is not endemic. The prevalence and severity of fluorosis in the higher age groups is almost certainly due to longer exposure to F.

X-rays of cervical spine (Figure 15), rib cage (Figure 16), lumbar-dorsal spine with pelvis (Figure 17), forearm (Figure 18), and lower limb (Figure 19) of 2-3 fluorotic subjects of each village showed increased bone mass and density as well as exostoses, calcification of ligaments and interosseous membranes, and osteosclerosis. These changes become more progressive with increase in age and F concentration in the water and provide further evidence of skeletal fluorosis in these villages. Other radiological changes have also been observed as described elsewhere.[27,28]

Figures 12-14. Cases of skeletal fluorosis showing secondary neurological complications: paraplegia and quadriplegia

Figures 15-19. Cervical and dorsal spines showing extreme osteosclerosis; lipping and osteophytosis (Figures 15 & 17); osteosclerosis of the pelvis with calcification of ligaments (Figure 17); contrast of the osteosclerosis bony cage with radiolucent lungs and clavicular involvement (Figure 16); calcification of interosseous membrane between radius and ulna bones of forearm (Figure 18); and bony exostosis in tibia (Figure 19)

General skeletal fluorosis directly affects the economy of villagers (mostly tribespeople) in the areas studied, by causing illness and debilitation not only in humans but also in their domestic animals, on which they depend for their basic income. Hence, provision of defluoridated drinking water and health education aimed at abating fluorosis are highly desirable in these districts of Rajasthan. The present study also significantly expands our knowledge of fluorosis.

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