FLUOROSIS INDUCED BY DRINKING BRICK TEA

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SUMMARY: Fluorosis in China has been known to be induced by two main causes. One is water-dependent fluorosis caused by a long-time consumption of high-fluoride (F) containing water. The other is called "coal-burning type fluorosis", caused by inhalation of air polluted by coal smoke and/or ingestion of food exposed to coal smoke. We conducted a study on a group of Tibetan residents who regularly consumed brick tea containing high F levels. Many of the adults and children were found to be afflicted by fluorosis. Our results led us to present a third type of fluorosis in China called "brick tea type fluorosis".

Key words: Brick tea; China; Comparative study; Endemic fluorosis; Tibet.

Introduction

Fluorosis in China has been known to be induced by two main causes. One is water-dependent fluorosis caused by consumption of high-fluoride (F) containing water over a long period of time. Another is known as "coal-burning type fluorosis" and is caused by inhalation of air highly contaminated with coal smoke and/or ingestion of food exposed to coal smoke.[1] In this paper, the existence of a third type of fluorosis called "brick tea type fluorosis" is presented. The disease is caused by prolonged consumption of brick tea, common among the Tibetan residents in southern and western parts of China. The disease initially affects the developing teeth, leading to dental fluorosis. As the disease then affects other parts of the body, it causes adverse effects on the patient's joints, muscles, and nervous system. Symptoms include general pain, osteoarticular deformation and dysfunction, which cause the patients to lose their viability and workability.

Materials and Methods

We conducted our study in Daofu County in Sichuan Province, situated in the northwestern part of Qin-Tibet Platte in China. The elevation of the Platte ranges from 2,900 to 5,800 m, and the inhabitants are a group of very isolated people. Random samples were collected according to the WHO/FAO "Guide to Research on Intake of Chemical Pollutants".[2] Tea drinking habits and food consumption were studied among 15 Tibetan and 15 Han families. For determination of F in food, collected food samples were dried and the dried samples were ground to pass a 0.45 mm sieve. A 1.00 g sample was placed in a 50 mL volumetric flask, followed by the addition of 10 mL 1 N HCl. The mixture was allowed to stand for 1 hour, with gentle shaking. A 25 mL total ionic strength adjustment buffer, made of an equal volume of 3 M sodium acetate and 0.75 M sodium citrate, was then added and the solution was made to volume with distilled deionized water. F concentrations of the resultant sample solution were then determined by the F ion

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specific electrode method. F contents in water and tea water samples were determined by the same method. Urinary samples were collected from 30 Tibetan and 30 Han children, and the F concentrations were determined also by the F ion specific electrode method.

Dental fluorosis among 375 Tibetan and 161 Han children between ages 8 and 15 was investigated following Horowitz's TSIF classification and standards.[4] Additionally, 685 Tibetan adults over 16 years of age were studied for signs of skeletal fluorosis, by following the method described in "The Prevention and Cure Standard of Endemic Fluorosis" published by the Department of Endemic Disease Prevention and Cure, Chinese Ministry of Health.

Results and Discussion

Fluoride concentrations in the source water consumed by both Tibetan and Han residents were found to be low and there were no significant differences in the F levels among the water samples studied (Table 1). However, average F concentration in the brick tea water (2.59 mg/L) drunk by the Tibetan families was 4.7 times higher than that of tea water (0.55 mg/L) consumed by the Han families. The Han habitants drink green tea or flower tea made from tender leaves containing much lower levels of F.[3] Based on observations and analysis of F levels in brick tea, we found that the high F content of the brick tea was due to the high F levels in the raw material. Tea trees absorb high amounts of F from soil and store it in the leaves. As the trees age, the F concentration increases.[6]

Presently, there is no international intake limit for F. The 1989 RDA (Recommended Dietary Allowances) of the USA recommend a F intake limit of 2.5 mg/day for children and 1.5 to 4.0 mg/day for adults. According to "The Plan for Primary Health Care" published by the Chinese Ministry of Health in 1989, adult fluoride intake should not exceed 4.0 mg/day. Assuming that the limit of F intake for children is 2.5 mg/day and that for adults is 4.0 mg/day, the daily F intake of the Tibetan children and adults was 2.2 times and 2.6 times, respectively, higher than the standards (Table 2). The F intakes of the Han children and adults were much lower than the standards. Stepwise analysis showed that the F in brick tea and Zanba (the main Tibetan food) was an important factor influencing the total F intake. Their correlation coefficients were 0.99 and 0.96, respectively (Table 3).

The Tibetan children in the study area were at a medium level of dental fluorosis, as classified by Horowitz's index of dental fluorosis.[4] Clinical symptoms included chalk-like and stain-defect pathological changes (Figures 1 and 2). According to the index, the Han children did not have dental fluorosis. The concentrations of urinary F were considered as an indicator of F body burden. Watanabe *et al*[5] reported that 18-35% of the daily F intake was excreted within 24 hours. Average daily F intake by Tibetan children was found to be about 5.4 mg (Table 2) and the daily urinary F excretion was 1.84 mg/L (Table 4). Since 35% of ingested F was excreted within 24 hours, the daily F accumulation was estimated to be 3.57 mg. Accumulation of such a high F level may account for the high prevalence of dental fluorosis among Tibetan children.

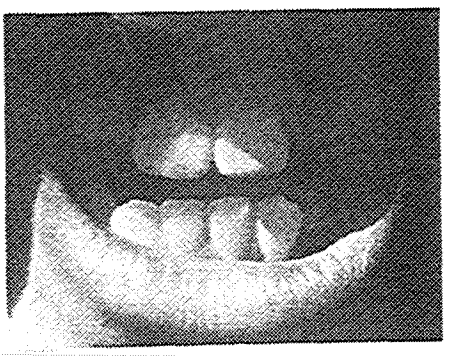

Figure 1. Chalk type dental fluorosis

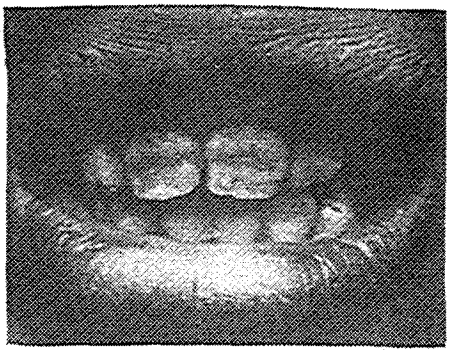

Figure 2. Flaw type dental fluorosis

TABLE 1. Concentrations of fluoride in source water and tea water

Inhabitant ethnic group	Concentrations of fluoride (mg/L)			
	Source water		Tea water	
	n	$\bar{x} \pm SD$	n	$\bar{x} \pm SD$
Tibetan	3	0.11 ± 0.069	5	2.59 ± 1.73
Han	3	0.11 ± 0.070	5	0.55 ± 0.16

TABLE 2. Daily fluoride intake by children in study areas

Inhabitant ethnic group	age (years)	Average F intake from various sources (mg)						Total (mg)
		zanba	rice	flour	vege-table	brick tea	green tea	
Tibetan	8-15	1.28	0.085	0.009	0.14	3.89	-	5.404
	> 15	2.05	0.17	0.132	0.28	7.80	-	10.432
Han	8-15	-	0.34	0.132	0.14	-	0.83	1.44
	> 15	-	0.34	0.40	0.42	-	1.38	2.54

TABLE 3. Correlation analysis between total fluoride intake and the source of fluoride

F source	Total F intake	Correlation	Equation of rectilinear	*p*
Tea	y_1	0.99	$y_1 = 1.368x + 0.24$	0.02
Zanba	y_2	0.96	$y_2 = 3.311x + 1.75$	0.03
Rice	y_3	-0.2620	$y_3 = 10.86x + 8.25$	0.74
Flour	y_4	-0.0371	$y_4 = 0.357x + 1.8$	0.91
Vegetable	y_5	-0.1912	$y_5 = -6.17x + 7.94$	0.81

TABLE 4. Dental fluorosis morbidity rate and urinary fluoride levels

Inhabitant ethnic group	n			Patients with dental fluorosis		Index of dental fluorosis	Urinary F (mg/L)	*p*
	M	F	Total	n	%			
Tibetan	213	162	375	182	51.2	1.33	1.84 ± 1.03	0.01
Han	86	75	161	18	11.0	0.17	0.71 ± 0.40	

TABLE 5. Range of fluoride concentrations (mg/kg) in different Chinese tea leaves

Longjin Tea	10.1 - 12.7
Oolong Tea	14.2 - 16.7
Black Tea	23.6 - 52.1
Brick Tea	493.2 - 1000

Studies on the 685 Tibetan adults showed that 216 people (31.5%) had clinical signs of skeletal fluorosis. These people were classified into three grade groups depending on the number and symptoms. Fifty-six persons (8.1%) were classified as belonging to Grade I as they had three or more types of clinical symptoms; 154 persons (22.5%) to Grade II, with clinical symptoms and signs of skeletal fluorosis; and 6 persons (0.9%) to Grade III, with signs of skeletal fluorosis plus humpback, paralysis and other symptoms. Frequency of manifested symptoms included: 39.2% with joint pain; 26.1% with lumbago; 16.9% with numbness in the extremities; 4.1% with tetany; and 3.8% with hand and foot rigidity. Statistical analysis showed no significant differences in morbidity rate between the males and females (Table 4).

Further tests were performed on 160 individuals with signs of skeletal fluorosis. The results showed that all had upper limb flexion; 69.4% had difficulty touching their shoulders; 31.9% had difficulty touching their ears; 30% had difficulty extending their forearms; 56.7% had difficulty squatting; 5.6% had spine rigidity; and 3.7% had paralysis and were humpback. One hundred and eight persons had three signs of skeletal fluorosis in this investigation. In a random sample, 24 out of 31 people were diagnosed with skeletal fluorosis by X-ray examination, giving a rate of 77.4%. Among them, 8 were in the initial stage of the disease, 9 were in Grade I, 7 were in Grade II and most of them showed a pathological change in the forearm X-rays. Results of X-ray examination indicated that more than 87% of the group had main effects of fluorosis, including osteoporosis, radial collateral interosseous membrane ossificational hyperplasia, narrowing of the joint space, cystic degeneration under the articular surface, and ulnar and radial collateral interosseous membrane ossificational hyperplasia.

Brick tea is made of rough old tea leaves and branches

Excluding the possibility of water and air as causes of fluorosis, it was found that among the Tibetans in Daofu County, about 94% of both the children's and the adults' F intakes was derived from brick tea. We conclude, therefore, that drinking the brick tea with high levels of F (Table 5) has led to the epidemic of brick tea type fluorosis.

Keto (42 years old) could not bend his arms to touch his shoulders because of skeletal fluorosis

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