Diagnosis of Endemic Skeletal Fluorosis: Clinical Examination vs. X-Rays

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Objective: To compare the diagnosis of endemic skeletal fluorosis by means of clinical examination to diagnosis by x-ray, in order to provide a foundation for revising standards of clinical diagnosis for endemic osteofluorosis.

Method: The study was carried out using existing data. The fluoride levels of 15 villages in the Qianan and Nongan counties of Jilin, where residents continue to drink from naturally fluoridated sources, were divided into 11 categories based on the fluoride content of the water: 0.5, 1.0, 1.5, 2.0, 2.2, 2.4, 3.0, 3.5, 4.0, 6.0, and 7.0 mg/L. 675 residents between the ages of 16 and 60 who had lived in the area for at least 10 years were selected as subjects; the results of their diagnosis by either clinical examination or x-ray examination were analyzed and compared.

Results: For subjects drinking water with fluoride concentrations of 2.0, 2.2, 2.4, 3.0, and 4.0 mg/L, clinical detection rates (21.43%, 22.45%, 21.28%, 19.05%, 38.89%) were markedly higher than x-ray detection rates (0, 2.04%, 9%, 4.76%, 12.96%; $\chi 2 = 7.96, 9.49, 11.19, 4.08, 9.45$, $p < 0.05$). The detection rate for x-rays were zero at fluoride concentrations of 2.0 and 2.4 mg/L, and still relatively low at 3.0 and 4.0 mg/L. At fluoride concentrations of 0.5, 1.0, 1.5, 3.5, 6.0, 7.0 mg/L, the difference between the clinical detection rates (1.00%, 4.44%, 7.23%, 18.00%, 54.39%, 49.18%) and x-ray detection rates (0, 2.22%, 3.61%, 8.00%, 36.84%, 52.46%) was not statistically significant ($\chi 2 = 1.00, 0.17, 0.47, 2.21, 3.54, 0.13$, $p > 0.05$)

Conclusion: With both the clinical and x-ray method, the detection rate increases with the concentration of fluoride in the local water, and the clinical detection rate increases more reliably with concentration than the x-ray detection rate.

Key words: Osteofluorosis; X-rays; diagnosis; water consumption; results assessment

Osteofluorosis is a key indicator for endemic fluoride poisoning. Generally speaking, osteofluorosis is diagnosed by means of either clinical examination or x-ray. As part of the work in preventing and treating this disease, the consistency of results between clinical and x-ray examinations needs to be better understood; this will provide an important benefit with respect to understanding and choosing diagnostic techniques as well as improving diagnostic standards. Using materials from the key research project "Quantitative Epidemiological Research on Endemic Fluoride Poisoning "[1] launched in 1984 by the Endemic Fluorosis Scientific Committee of the Central Office of Endemic Diseases, the authors have carried out a comparison and analysis of osteofluorosis diagnoses by either clinical examination or x-ray, offering a new reference for future prevention and treatment work and the creation of diagnostic standards.

1. Materials and Methods

1.1 Place of Investigation: Our study uses materials previously collected from 15 villages from endemic areas in the Qianan and Nongan counties of Jilin province; these villages have existed at least 50 years and still use their original water source. Detailed records have been kept about the fluoride concentration of the drinking water of these villages. (The concentration was measured using the ion selective electrode method, with a range of variation less than 0.3 mg/L). The residents do not have the habit of drinking tea, are not very mobile, are of uniform ethnic composition, have similar natural surroundings, economic status, and living and working conditions, and are not subject to other sources of fluoride poisoning such as industry or coal-burning. The 15 villages were divided into 11 levels based on the fluoride concentration of their water: 0.5 mg/L (Xiaowangjia Village, Rangzijing Village); 1.0 mg/L (Xigengjia Village, Zhongrenzi Village); 1.5 mg/L (Majiawo Village, Jianzijing Village); 2.0 mg/L (Linjia Village); 2.2

mg/L (Xiguang Village); 2.4 mg/L (Bijiadian Village); 3.0 mg/L (Dongcang Village, Huangtai Village),; 3.5 mg/L (Houxun Village); 4.0 mg/L (Loujia Village); 6.0 mg/L (Yexiaopu Village); and 7.0 mg/L (Anzijing Village).

1.2 Subjects: From the residents of villages at each concentration level subjects between the age of 16 and 60 who had lived in the village for at least 10 years were selected. The subjects were divided into 5 age groups with cut-offs at 21, 31, 41, and 51; there were 10-15 subjects from each age group from each fluoride level, with an even balance of male and female. A total of 675 subjects were selected in all.

1.3 Targets: Includes clinical examinations of the bone and joints as well as frontal x-rays of the forearm (including the elbow) and the thigh (including the knee).

1.4 Diagnosis Standard: Diagnosis of osteofluorosis by both clinical examination and x-ray was made according to "Endemic Osteofluorosis Diagnostic Standards" (WS 192-2008).

1.5 Statistical Analysis: A $\chi 2$ test was used to compare the differences in the detection rates between clinical examination and x-rays for the various fluoride levels; $p < 0.05$ indicates a statistically significant difference.

2. Results

For subjects drinking water with fluoride concentrations of 2.0, 2.2, 2.4, 3.0, and 4.0 mg/L, there were marked differences in the detection rates of the two diagnostic methods ($\chi 2 = 7.96, 9.49, 11.19, 4.08, 9.45$, $p < 0.05$), with the rates for clinical examination higher than x-ray detection rates; in particular, at fluoride concentrations of 2.0 and 2.4 mg/L the clinical detection rate was 21.43% and 22.45% while the x-ray detection rate was zero. However, at fluoride concentrations of 0.5, 1.0, 1.5, 3.5, 6.0, 7.0 mg/L, the difference between the clinical detection rates (1.00%, 4.44%, 7.23%, 18.00%, 54.39%, 49.18%) and x-ray detection rates (0, 2.22%, 3.61%, 8.00%, 36.84%, 52.46%) was not statistically significant ($\chi 2 = 1.00, 0.17, 0.47, 2.21, 3.54, 0.13$, $p > 0.05$). When the fluoride concentration is 3.0 mg/L, the x-ray detection rate is rather low (only 4.76%), but it rises to 12.96% at 4.0 mg/L, though this is still markedly lower than the clinical detection rate of 38.89%. The detection rate of both clinical and x-ray examinations increases with the increase in water fluoride concentration, giving consistent results when the fluoride concentration is relatively low or relatively high. The clinical detection rate increases more reliably with the fluoride concentration than the x-ray detection rate, see Table 1.

3. Discussion

Previous investigations[2-3] have demonstrated that the results of clinical and x-ray diagnoses of osteofluorosis are consistent. The present study shows that the detection rate of clinical examination increases more regularly with water fluoride concentration than the x-ray detection rate. It has been previously noted by Chen et al.[4] that, when comparing clinical and x-ray detection rates for osteofluorosis, the x-ray detection rate did not vary regularly with the fluoride concentration. When investigating the relationship between the fluoride concentration of drinking water and fluoride poisoning detection rates, Shi[5] found a clinical detection rate of 7% in areas with less than 2.5 mg/L of fluoride, but x-rays were not able to diagnose a single case. Geever et al[6] compared the bone necropsies of 37 individuals residing in areas with drinking water fluoride concentrations of 1.0-4.0 mg/L with those of 33 individuals living in areas with drinking water fluoride concentrations of less than 0.5 mg/L; a microscopic examination showed no differences between the two.

In previous research which concluded that clinical and x-ray diagnoses of fluoride poisoning were consistent with each other, the authors used full body x-rays[2-3]. Across the entire skeleton, the three locations which yielded the most positive diagnoses were the pelvis, the forearm, and the thigh. The rate of diagnosis using these three locations together was 100%; with 2 locations it was 90%; and with one of the pelvis, forearm, and thigh it was 83.33%, 80.00%, and 73.33%, respectively[2-3]. Therefore, increasing the scope of the examination can increase the x-ray diagnosis rate. Even though the diagnosis rate could clearly be improved by adding pelvic or other x-rays to the forearm and thigh x-rays used here, at water fluoride concentrations of lower than 3.0 mg/L, the detection rate for x-rays is nevertheless markedly lower than the clinical detection rate; in particular, at 2.0 and 2.4 mg/L x-rays did not detect a single case, indicating that the changes visible by x-ray present later than clinical symptoms. In other words, the effects of fluoride on the body may first manifest in symptoms such as joint pain and restricted limb movement and,

Table 1: Osteofluorosis Detection Rates of Clinical and X-Ray Examinations for Various Drinking Water Fluoride Concentrations					
Fluoride Concentration (mg/L)	Total Number of Subjects	Clinical Exam		X-Rays	
		Diagnosed Subjects	Detection Rate (%)	Diagnosed Subjects	Detection Rate (%)
0.5	100	1	1.00	0	0
1.0	90	4	4.44	2	2.22
1.5	83	6	7.23	3	3.61
2.0	42	9	21.43	0	0*
2.2	49	11	22.45	1	2.04
2.4	47	10	21.28	0	0*
3.0	42	8	19.05	2	4.76*
3.5	50	9	18.00	4	8.00
4.0	54	21	38.89	7	12.96*
6.0	57	31	34.39	21	36.84
7.0	61	30	49.18	32	52.46
*Difference with corresponding clinical detection rate is significant, $p < 0.05$					

although the symptoms of osteofluorosis are not specific to the disease and may easily be confused with other kinds of arthritis[7], a careful analysis can detect differences between them.

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