FURTHER OBSERVATIONS ON RADIOLOGICAL CHANGES OF ENDEMIC FOODBORNE SKELETAL FLUOROSIS

by

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SUMMARY: Among radiological changes in 396 cases of foodborne skeletal fluorosis, from four endemic areas in Guizhou, China, the author has observed osteoporosis, osteomalacia and impaired bone growth in addition to previously recorded findings of osteosclerosis, bone prominences, joint changes, and calcification of peripheral arteries. The deformity of genu valgum, a manifestation of osteomalacia, was encountered in one of the endemic areas. Radiographic appearances varied between individuals, from one area to another, and depending on age.

KEY WORDS: Fluorosis, skeletal; China; Osteosclerosis; Osteoporosis; Osteomalacia; Skeletal fluorosis, foodborne.

Introduction

Since his preliminary findings on radiological changes of foodborne skeletal fluorosis appeared in 1981 (1), the author has made additional observations.

Material

In this report of 396 cases of skeletal fluorosis, 240 were males, 156 were females. They ranged in age from 3.5 to 70 years; 45 were under 19 years old.

The patients came from endemic areas I, II, III, and IV, in Guizhou, China, with different degrees of prevalence. The fluoride levels in drinking water and in some food items in the four areas are tabulated in Table 1.

Table 1

Fluoride Levels in Different Areas

Area	No. of Cases	F^- (ppm) in Water	mgF^-/kg in Rice	Corn	Potatoes
I	92*	0.15-0.18	3.3	5.2-6.6	0.7-0.8
II	70	0.1	2.4-8.1	4.4-13.5	1.2-5.1
III	23	0.51	4.9-8.3	5.0-17.8	Unassayed
IV	211	0.07-0.33	11.8-32.1	16.7-17.2	16.4-45.3

*34 cases previously reported (1) are included.

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The above cases were diagnosed as skeletal fluorosis based on mottled enamel, radiological changes, and the high fluoride levels in food.

Results

The radiological findings are summarized under headings and subheadings as shown in Table 2.

Table 2

Radiological Findings in 396 Cases of Endemic Skeletal Fluorosis

1. Axial osteosclerosis
   a. Thickening of trabeculation
   b. Thickening of cortex
   c. Encroachment of the medullary cavity by compact bone
2. Osteoporosis
   a. Generalized osteoporosis
   b. Peripheral osteoporosis
3. Osteomalacia
   a. Peripheral osteomalacia
   b. Regional osteomalacia
4. Bony prominences
   a. Ectopic ossification of ligaments, tendons, aponeuroses, interosseous membranes, and muscular attachments
   b. Periosteal new bone formation
5. Joint changes
   a. Narrowing of articular spaces
   b. Periarticular osteophytes
   c. Intra-articular free bodies
6. Impaired bone-growth
   a. Growth arrest lines
   b. Multiple compact contours
   c. Failure of modelling
7. Others
   a. Calcification of peripheral arteries
   b. Cyst-like radiolucences

Osteosclerosis and formation of bony prominences on surfaces of bones, which are recognized characteristic changes of fluorosis and the mainstay for establishing the diagnosis, were noted in most of the patients. Osteosclerosis was especially prominent in axial bones of the spine, pelvis, and ribs, although peripheral bones were not spared.

Osteoporosis was either generalized or peripheral according to the sites involved. Generalized osteoporosis, encountered in 20 cases above age 40, involved the whole skeleton. Its radiological features were similar to those of senile osteoporosis. Associated characteristic bony prominences were the basis on which the diagnosis of fluorosis was established. However, the possibility of fluorosis complicated with senile osteoporosis cannot be excluded. Peripheral osteoporosis, which was encountered frequently, was prominent chiefly in peripheral bones, where trabeculae were partially thinned or disappeared; but the remainder, usually the lines-on-force trabeculae, were prominent and coarsened, forming intertwining networks. In these patients, mild osteoporosis was also fre-

quently found in axial bones showing patchy porotic areas, usually in bilateral iliac wings.

According to the sites involved, osteomalacia was either peripheral or regional. In peripheral osteomalacia, the lower extremities were chiefly affected, but the upper extremities and other bones were not spared.

The cortex was thinned or laminated, trabeculae were blurred, density was decreased and was often associated with genu valgum (Fig. 1), which usually began in childhood and progressed over many years. In 10 children, osteomalacia involved the pelvis, forming tri-foliative deformity due to intrapelvic protrusion of bilateral acetabula. The peculiarity of peripheral osteomalacia was its frequent association with axial osteosclerosis. Increased weight of sclerosed axial bones was a factor aggravating the deformity of the lower extremities. Regional osteomalacia was manifested by a radiolucent zone in metaphyses adjacent to epipheses, or by an arcuate radiolucent zone just below the iliac crests (Fig. 2). Presumably, because the rate of new bone formation is too rapid to keep pace with subsequent calcification, a zone of poorly calcified osteoid seam is formed.

Figure 1

Male aged 39, Marked Bilateral Genu Valgum

Figure 2

Male, aged 30, Marked Osteosclerosis of Lumbar Vertebrae and Pelvis

Broad radiolucent arcuate zone at ilium on each side, just below iliac crest.

Radiological features of bony prominences (Fig. 3) and joint changes have been described previously in detail (1). Often growth arrest lines occurred in the lower end of the femur and in the upper end of the tibia (Fig. 4). Sometimes, multiple dense arcuate lines were distinguished just below the brim of the ilium. Multiple dense contours were often noted in the ilium just around the end plate of the acetabulum (Fig. 5). These changes indicate repeated arrest of osteoblastic activity during bone growth. Failure of modelling was occasionally seen, resulting in expansion of shafts and metaphyses (Fig. 6). Moreover, calcification was en-

Figure 3

Male, aged 40

Multiple bony prominences on radius and ulna.

Figure 4

Male, aged 11

Multiple growth arrest line in the metaphyses of femur and tibia.

Figure 5

Male, aged 15

Multiple contours around end plate of acetabulum.

Figure 6

Male, aged 9

Multiple cyst-like radiolucences in metacarpal and phalangeal bones. Note expansion of these bones.

countered in one case, with cyst-like radiolucences in four cases (Fig. 6).

Radiographic appearances varied in different areas. Osteosclerosis, bony prominences, and joint changes were noted in all areas, whereas osteomalacia and impaired bone growth appeared only in Area IV where the fluoride levels in rice, corn and potatoes were much higher than in the same produce from other areas. The appearance of osteomalacia and impaired bone growth in a fluorosis area suggests intake of large amounts of fluoride.

Radiographic appearances varied between individuals. Conflicting changes such as both decreased and increased density, coarsened, thinned and blurred trabeculae, coexisted not only in different bones of one individual, but also in one and the same bone. Some cases showed axial osteosclerosis exclusively, others axial osteosclerosis in association with peripheral osteoporosis or osteomalacia. In the pelvis, patients often showed decreased density with coarsened, rarified trabeculae intertwining in bilateral iliac wings and increased density in regions adjacent to articular surfaces and acetabula. Combinations of various changes produced a wide spectrum of radiographic patterns.

Radiographic appearances also varied from age to age. In younger cases osteosclerosis, bony prominences and joint changes were less marked. Impaired bone growth and regional osteomalacia were encountered chiefly in children and youth. In children below age 5, osteosclerosis was manifested as coarse trabecular striations or networks mixed with scattered dense spots of about 1-3 mm diameter found in iliac bodies, metaphyses of long tubular bones and elsewhere. These spots resulted presumably from en-face view of coarsened trabeculae. The striations, networks, and spots tended to increase in number, become progressively thicker, denser and hazier until sclerosis of spongiosa began to obliterate the demarcation between them and the cortex after about age 10. Below age 15, bony prominences and joint changes were never noted which explains why limitation of movement was rare in children.

Discussion

The present report substantiates the author's observation that,in endemic areas of Guizhou, China, food is an important source of fluoride. According to Li Ribang et al. (2) fluoride in food is higher than usual in a Guizhou fluoride area, because coal is used when baking food. Li Xianji (3), who studied the geological and environmental conditions in Guizhou. believes that fluoride in food can come from soil as well as from baking with coal. Obviously the practice of addition of fluoride to water supplies where it contains less than 1 ppm, is unfit for Guizhou.

Although fluorotic genu valgum, a world-wide problem, has been reported in India (4) and South Africa (5), this is the first report of it in China, where it is confined to certain endemic areas. After studying the four areas, the author concludes that the dose of fluoride influences its occurrence. Whereas in this series, a 3.5 year old child was the youngest with

skeletal fluorosis, fluorosis might begin even earlier, perhaps during the fetal period. Radiographs of the 3.5 year old child and other children showed mild osteosclerosis with trabecular thickening. Among them, osteoporosis, which has been regarded as an early manifestation of fluorosis was not prominent. It seems unlikely in our cases.

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ENVIRONMENTAL FLUORIDE AND METABOLIC BONE DISEASE AN EPIDEMIOLOGICAL STUDY (FLUORIDE AND NUTRITION INTERACTIONS)

by

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SUMMARY: Epidemiological, clinical, nutritional, biochemical and radiological surveys were performed in nonendemic fluorosis areas to determine the relationship between endemic skeletal fluorosis and accompanying metabolic bone disorders.

In individuals with inadequate nutrition, en-

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