

# OCCUPATIONAL SKELETAL FLUOROSIS

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Fluorosis in industry has been discussed by many authors but relatively few cases have been reported which originated from the electrolytic production of aluminum.

In the following presentation, the clinical, roentgenological and stomatological aspect of the disease will be discussed on the basis of four cases. Two of these patients exhibited the first stage, the two others - the second stage of the disease. The workers had been exposed to fluoride up to approximately 12 years.

It is not difficult to assess the degree of mineralization of bones by X-rays during the second and third stage of the disease. In its initial phase, however, a certain subjective element is bound to enter into the diagnosis. In our cases, X-rays were taken in AP projection of the thoracic and cervical spine, the pelvis, forearms, lower leg, right humerus, and thorax. Whenever indicated, additional films were taken.

The first radiological signs of skeletal fluorosis manifest themselves in the spongiosa of the lumbar vertebrae, the pelvis and the ribs. The vertebral bodies lose their sharp demarcation and show a hazy outline. In the long bones the border of the cortex becomes indistinct.

During the second and third stage, the periostium is thickened and the ligaments are ossified, especially at their attachments to the bones. Ossification of the interosseous membrane at the interosseous crest of the radius is a characteristic feature of the disease. Typical stalactiform osteophytes occur on the proximal portion of the metaphysis of fibula and tibia. Ordinarily, the presence of an exostosis is not diagnostic of fluorosis unless there is simultaneous osteosclerosis of bones. Similarly ossification of the ligamentum sacro-tuberale and sacro-spinale may be encountered in individuals who are not exposed to fluoride compounds. Only if calcification of ligaments is combined with osteosclerosis can it be considered of fluorotic origin. In young workers we observed frequently a distinct sclerosis of spongy bone in its central portion without formation of exostoses. In these individuals, the sclerotic condition tends to subside when the workers discontinue their job. In only rare instances is the disease progressive once the afflicted individuals are no longer exposed to fluoride.

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In differential diagnosis, osteosclerotic metastases of malignant tumors and Paget's disease can be readily differentiated from fluorosis. The distinction of skeletal fluorosis from osteomyelosclerosis and osteosclerosis due to chronic kidney disease is more difficult.

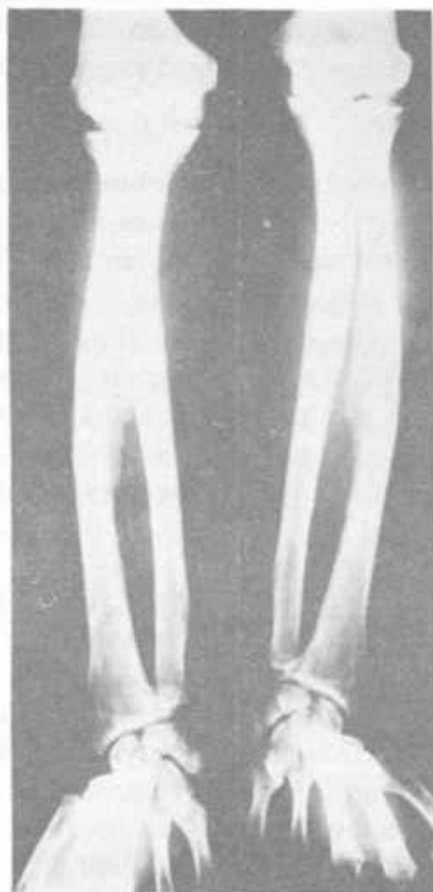
In the cases described below, extracted teeth and roots were analyzed, an occupational history and X-rays were taken but fluoride assays in bones could not be made. The diagnosis fluoride-osteosclerosis was established on the basis of clinical and laboratory findings.

For the fluoride assays of teeth, we employed the procedure of Powell and Sayer reported in 1953 (1). Optical and chemical conditions were set up for measurements of fluorescence. The following materials and apparatus were used: Eriochromrot B (Geigy, Swiss/EB), AlCl<sub>3</sub>. 6H<sub>2</sub>O (Reanal, Hungary) and standard chemicals of reagentgrade purity (Lachema, Czechoslovakia). All fluorescence and excitation spectra were on a Farrand type fluorescence spectrometer - equipped with a Brown-Honey-Well recorder. All spectra were uncorrected; pH measurements were carried out on a "pH meter 22" (Radiometer, Denmark) with a glass electrode.

### Case Reports

Case 1: M. B., 48 years old, case #11008/1965 has been an active metallurgist for 7 years in an aluminum refinery. He complained of backache of two years standing, usually aggravated upon arising in the morning, and of pains in the bones of the forearms and lower legs. He was an asthmatic, somewhat obese with well-developed musculature. His teeth were healthy, except for the root of No. 6 at the lower left and No. 7 at the upper right. The roots of the two missing teeth contained excessive fluoride, namely up to 47.2  $\mu$ g in 100 mg (472 ppm) tooth substance (controls 160 to 200 ppm). The movements of the spine were restricted. The blood pressure was 140/95; CBC 4,625,000; WBC 4,400; Hb 90%; Neutr. seg. 97%; lymphocytes 30%; eosinophiles 2%; monocytes 1%; VDRL negative; urine examination negative. The glucose tolerance test ranged from 90 to 155 mg%; the serum albumin totaled 7.2 g%; the electrophoretic pattern was normal. Serum calcium 9.8 mg%; inorganic phosphorus 2.9 mg%; sodium 131 mEq/l - Potassium 4 mE/l; acid phosphatase 1.5 units; alkaline phosphatase 6.6 units; total cholesterol 210 mg%; urinary Ca 150-170 mg/24 hrs. The urinary fluoride ranged from 2.8 mg/24 hrs. to 6 mg/24 hrs.

The X-rays showed marked osteosclerosis in the central portion of the spine, the pelvis and the ribs. The spongiosa was indistinctly outlined, the trabeculae were thickened. Both sacrotuberal ligaments and the interosseous crest of radius and ulna were ossified. The elbow joints showed evidence of deformant osteoarthritis. Fig. 1: At the lower extremities small osteophytes were present bilaterally in the upper portion of the metaphyses below the knee and at the linea poplitea at the attach-

Fig. 1Forearm (Case 1)

Osteosclerotic forearm. Increased density, narrowing of medulla. Ossified interosseous membranes.

Fig. 2Lower Leg (Case 1)

Osteosclerosis alternating with osteoporosis. Periosteal apposition of bone.

Case 2: J. B., 59 years old, #915/1965 had been employed actively in the electrolytic production of aluminum for 11 years. During the past year he showed marked weakness in the lower extremities and the lumbar spine, and occasional paresthesias of the thigh. His musculature was well developed. On the lower jaw tooth #3 and 7 were missing and replaced by a denture; the 7th upper left tooth showed a crown; tooth 1 and 3 appeared normal; all other teeth were missing. One of the extracted teeth contained the unusually high value of 797.35 mg of F per 100 gram or 7973.5 ppm. Spleen and liver were not enlarged. The spine and extremities showed no restriction in movement. The blood pressure was BP 150/80.

Laboratory tests showed RBC 4,700,000; WBC 4,800; Hb 84%; segmented neutrophils 58%; lympho 40%; mono 2%. The VDRL was negative;

the urinary findings normal. The glucose tolerance test was in the range of 95-207 mg%. Serum proteins totaled 7.3 g%; protein electrophoresis was within normal limits. Serum Ca was 8.8 mg%; inorganic P 3.6 mg%; Na 140 mE/l; K 4.6 mD/l; BUN 25 mg%. Phosphatase: acid 1 unit; alkaline 9.7 unit; total cholesterol 247 mg%. Urinary Ca 136 mg/24 hr. The 24 hour urinary fluoride determinations made since 1960 ranged from 1.65 mg/24 hr to 5.75 mg/24 hr.

X-rays showed marked osteosclerosis especially in the lumbar spine, pelvis and ribs. There was extensive ossification of ligaments and of muscular insertions. The outline of the vertebrae was indistinct. The structure of vertebral bone was completely opaque and dense. There was also evidence of deforming spondylitis. The pelvic bone showed osteosclerotic changes with bilateral ossification of the sacro-tuberal ligaments. The interosseous crest of the radius was sclerosed and the interosseous membranes calcified. The cortex of ulna and radius was thickened and dense. Osteophytes were present on the lateral aspect of the fibulae below the knee.

Two other individuals, A. B., 57 years of age, #4983/1966, and J. K., 46 years old #2968/1966, who had been working for 10 years in an electrolytic pot of the aluminum plant complained of pains in both knees and hands. Clinical and laboratory findings were normal, except that the urinary excretion of fluoride which had been determined regularly since 1960 was excessive. In patient A. B., it ranged from 1.15 mg/24 hr. to 3.42 mg/24 hr., in J. K. from 2.25 mg/24 hr to 4.5 mg/24 hr. The teeth of both individuals showed increased F levels namely 41.4 and 60.7 mg/100 mg (414 and 607 ppm) of tooth substance. X-rays showed only slight osteosclerosis mainly in the lumbar vertebrae, especially in the spongiosae. Both patients had evidence of osteoarthritis.

### Discussion

Dental fluorosis has been observed in children near this factory, but in adults the teeth showed no microscopic evidence of fluorosis. However, the abnormally high fluoride content of the teeth pointed to damage.\*

In 50 exposed individuals the width of compact bone and that of the spongiosa was measured for comparison with that of 50 non-exposed persons. No significant difference in the two groups could be detected. The appearance of the vertebrae on the other hand seemed to be significant as a diagnostic criterion.

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\*Peperkorn and Kähling (2) reported a yellow coating on teeth of workers of an HF plant in East Germany. In distinction to mottling of teeth this material was removeable by scraping the teeth.

All laboratory data were within the normal range, a fact which is not unusual in this disease. The 24 hour urinary fluoride excretion was of little value in the diagnosis of fluorosis. X-rays of bones and chemical analysis of teeth seem to be the most sensitive indicators of chronic fluoride intoxication.

### Conclusion

Four cases of skeletal fluorosis are described in individuals who had been working in an aluminum plant for periods up to 12 years. Two patients exhibited radiological changes indicative of the first stage of the disease and two of the second stage. All patients exhibited backache, pains in arms and legs and paresthesias. Laboratory tests were of little diagnostic value. Twenty-four hour urinary fluoride excretion ranged from 1.15 mg to 6 mg. The teeth contained unusually high fluoride levels.

### Bibliography

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