Part two of a series, this report describes microscopic findings in bones from persons exposed to 1.0 to 4.0 ppm fluoride in comparison with a series of controls. The study discloses no pathological condition that could be attributed to fluoride ingestion.

Pathological studies in man after prolonged ingestion of fluoride in drinking water

E. F. GEEVER, M.D., N. C. LEONE, M.D.,
P. GEISER, M.S., and J. E. LIEBERMAN, M.A.

PUBLIC HEALTH programs to prevent dental caries by artificial fluoridation of drinking water have always considered the possibility of cumulative toxic effects. The present studies were instituted to determine whether pathological changes could be correlated with prolonged ingestion of fluoride-bearing water.

In an earlier publication we reported the necropsy findings in persons who had lived in a community with a fluoride level of 2.5 ppm (*1*). This is 2½ times the level recommended for prevention of dental caries. Since necropsies do not routinely include microscopic examination of bones, a separate study of this phase of the question was undertaken. Persons coming to necropsy who had lived in communities with 1.0 to 4.0 ppm fluoride, naturally occurring or added, in the drinking water were the subjects.

Dr. Geever is pathology consultant, Dr. Leone is chief of medical investigations, and Miss Geiser is a nurse officer, National Institute of Dental Research, Public Health Service, Bethesda, Md. Mr. Lieberman is a mathematical statistician, Biometrics Branch, Division of Research Services, National Institutes of Health.

Material and Method

Necropsies were performed in Grand Rapids, Mich. (1 ppm), Colorado Springs, Colo. (2.5 ppm), Amarillo, Tex. (2.8 ppm), and Lubbock, Tex. (4.0 ppm). Bone specimens were obtained through the cooperation of local pathologists: Dr. Joseph Mann and Dr. Harold Bowman of Grand Rapids, Dr. Morgan Berthrong and Dr. Raoul Urich of Colorado Springs, Dr. Marie Shaw of Lubbock, and Dr. John Denko and Dr. C. P. Churchill of Amarillo. The series consisted of 37 persons who had resided for 10 years or more in the above communities. The majority, 24, were residents of Colorado Springs; they provided 65 bones for the study. The ages of the subjects, 17 men and 20 women, ranged from 36 through 90 years.

For comparison with the fluoride series, 33 persons, 24 men and 9 women, who had resided in essentially nonfluoride (less than 0.5 ppm) communities served as controls. They ranged in age from 21 through 87 years.

Most of the persons in both series died suddenly. The most common causes of death were trauma, coronary heart disease, and cerebral vascular accidents. Those with chronic illness and diseases known to affect bone structure were excluded. Thus, there were none with primary or metastatic bone cancer, long-standing cancer of other organs, or renal or parathyroid disease.

In most cases three bones were selected for the microscopic studies: the body of a lumbar vertebra, a portion of iliac crest, and the sixth rib. In addition, the lumbar intervertebral body joints were examined for possible changes in articular cartilage. Less often, the sternum was also studied. A few bone or joint specimens proved unsatisfactory for some phase of the study, with the result that the totals vary.

The bones were fixed in 10 percent formalin and forwarded to the National Institute of Dental Research. Decalcification was carried out using a 5-percent-formic-acid method. Paraffin embedding and sectioning were performed and hematoxylin and eosin stains were applied, according to routine procedures.

Fluoride analyses of most of the specimens in both these series (plus a few other specimens) were performed independently. The results are reported in a separate article, by Zipkin and colleagues, on pages 732–740 of this issue.

Parosteal and Marginal Tissue

Parosteal and marginal tissue consisted of laminated or loose collagenous elements often merging with and indistinguishable from periosteum. Striated muscle fibers, fat, blood vessels, lymph nodules, nerve trunks, or nerve ganglia were sometimes observed. In the sections of vertebra, the longitudinal ligaments were often included.

Focal, nonspecific, chronic inflammatory reactions were found in the marginal tissues of 4 bones from 3 persons in the control group. These foci were found adjacent to a lumbar vertebra in 3 bones and near the sternum in 1. Focal swelling and necrosis of striated muscle fibers were found in another control, a 59-year-old woman who died of rheumatic heart disease. The changes, found near lumbar vertebra, were not accompanied by inflammatory reaction.

In the fluoride-exposed group, inflammatory change was observed in tissues of only one person. It consisted of a fairly severe subacute, nonspecific parostitis of the rib. In both the fluoride and the control groups small marrow foci were seen occasionally in periosteal and parosteal tissue of the vertebrae. These foci were undoubtedly related to the marrow of the vertebral body.

Periosteum

The periosteal surface was often irregular, microscopically, in both series. The irregularity in itself followed no consistent pattern. Sometimes slender, frayed or fuzzy papillary projections of bone and basophilic material, presumably calcium, were seen. Occasionally, smooth deposits of bone bulged up over wider areas under the periosteum. In other instances,

Figure 1. Active osteoclasia and fibrosis, periosteum of iliac crest, 105X, 44-year-old man, resident 40 years of a community with a natural fluoride level of 2.5 ppm.

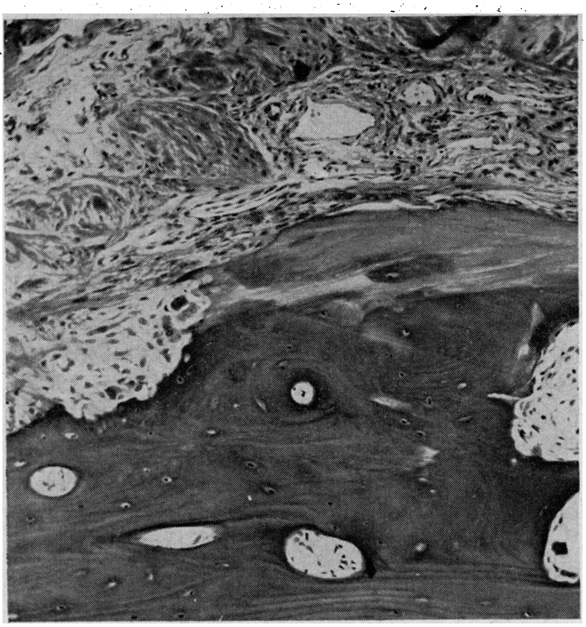

Figure 2. Active osteoclasia and fibrosis, periosteum and cortex of lumbar vertebra, 105X, 59-year-old man, control series.

new bone pushed up the periosteum in a trabecular pattern. Sometimes foci of bone were found in the parosteal tissue with no apparent connection to the subjacent bony cortex.

Irregularity in contour in some fields was due to old or active periosteal osteoclasia (figs. 1 and 2). Sometimes gaps were visible in the bone where blood vessels entered and the periosteum appeared to be the only barrier between the marrow and adjacent marginal tissue, particularly in the sections of vertebrae. The majority of the frayed or fuzzy papillary projections of bone and basophilic material appeared to be old and unaccompanied by cellular proliferation. However, small strips or foci of bright, eosinophilic, new and incompletely calcified bone (osteoid) could be observed also. Often cuboidal or columnar osteoblasts were seen nearby.

Surface irregularity was frequently found near the sites of tendon insertion in the sections of iliac crest in both groups. Often it was accompanied by cartilaginous changes and irregular basophilic staining presumably due to calcification (fig. 3). Irregularity due to extension of cartilaginous and basophilic stained material along the front periosteal surface away from the intervertebral joint and toward the midlevel of the vertebral body was often seen.

The criteria used in grading excessive bone or calcium deposition were based on the maximum degree of projection from adjacent surfaces as measured by an ocular micrometer, the maximum foci per standard low-power microscopic field, the number of fields affected, and the presence of extraperiosteal bone or basophilic stained foci independent of the adjacent cortex. Bones from the fluoride and control groups were examined alternately.

Irregularity in periosteal contour due to excessive bone or calcium deposition, or both, was found in 48 of a total of 94 satisfactory bone sections in 25 of the 33 controls (table 1). Similar changes were present in 35 of a total of 99 satisfactory bone sections in 24 of 37 fluoride-exposed persons. Focal, nonspecific inflammation was found in 3 bones in 3 controls and in 2 bones in 2 of the fluoride group.

Active osteoclasia was found not infrequently with 1 or 2 osteoclasts recognizable in the margins of typical Howship's lacunae. Arbitrary criteria were set up to evaluate increased activity. Since the tissue sections were only approximately equal in size, quantitation could also be only approximate. Grading was started at +, for a mild, or slight, increase based on

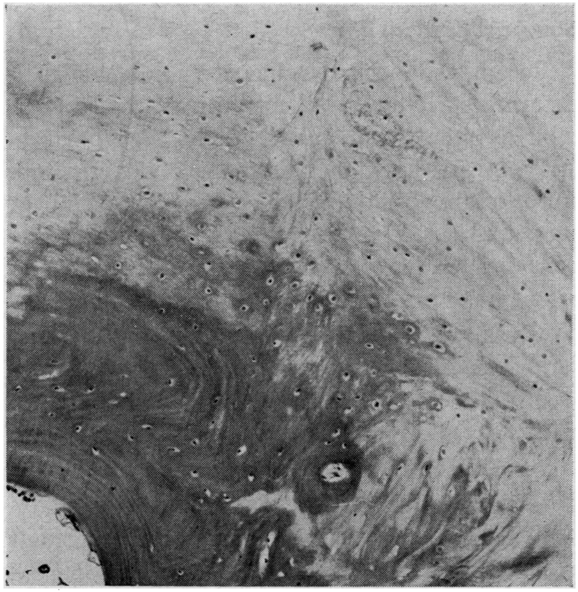

Figure 3. Parosteal and periosteal cartilaginous changes, iliac crest, 35X, 73-year-old woman, control series.

Table 1. Periosteal changes in persons ingesting fluoride and in controls

Periosteal changes	Fluoride series		Control series	
	Number bones	Number persons	Number bones	Number persons
Total examined	99	37	94	33
Irregular periosteal bony proliferation and/or calcification	35	24	48	25
Focal periostitis	2	2	3	3
Excessive active osteoclasia	4	4	3	3

2 to 4 multinucleated osteoclasts per low-power field associated with Howship's lacunae and present in more than one field. Grade ++, or moderate, was based on at least 5 osteoclasts, and grade +++, or severe, on 7 or more osteoclasts per low-power field. On the basis of this scale, ++ osteoclasia was observed in 2 bones and + in another for a total of 3 bones with such periosteal changes in 3 controls (table 1). In the fluoride group 2 bones showed a + increase, 1 a ++, and 1 a +++ increase in activity for a total of 4 bones in 4 individuals.

Compact Cortical Bone

Recently deposited bone (osteoid) could be determined by eosinophilic staining of the matrix, as mentioned above. This was particularly impressive when layers of various ages were arranged side by side. Configuration of cement lines, degree of cellularity, and appearance and arrangement of osteoblasts and osteocytes also aided. In the compact portion, swelling of endosteal cells was sometimes observed on surfaces abutting the marrow cavity, within the Haversian canals or within large open endosteal spaces. Sometimes such cellular arrangement was also associated with strips of bright eosinophilic new bone (osteoid). Other fields showed new bone layers without evident cellular activity. Serial section in such instances might have disclosed the presence of osteoblasts nearby. Some zones revealed what appeared to be mobilization and swelling of endosteal cells without evidence of new bone formation. This might have represented a preliminary phase in such a process.

The cortices of the rib and iliac crest were thicker than those of the vertebra, and the Haversian systems there were usually well defined. Sometimes, however, excessive decalcification made the lamellae appear delicate, poorly stained, and incompletely outlined.

An attempt was made to evaluate osteogenesis and osteoporosis objectively after the first survey of the material indicated that the differences in the amount of bone substance between the fluoride series and the controls would be slight, if there were any at all. No satisfactory method for such an evaluation could be

Table 2. Average coded measurements [1] for compact cortical bone, fluoride and control series

Bone category	Fluoride series	Control series	Both series
All bones	1. 550 (99)	1. 734 (95)	1. 640 (194)
Lumbar vertebra along articular cartilage	1. 316 (34)	1. 418 (31)	1. 357 (65)
Lumbar vertebra cortex elsewhere	1. 510 (36)	1. 608 (31)	1. 556 (67)
Rib cortex	1. 893 (29)	2. 148 (33)	2. 029 (62)

[1] Square root of measurements.

NOTE: Figures in parentheses are numbers of measurements.

Table 3. Analysis of variance, compact cortical bone measurements

Source	d.f.	Sum of squares	Mean square	F	$F_{.05}$
Mean	1	521. 95			
Total	193	45. 85			
Bone part	2	[1] 14. 59	7. 29	[2] 23. 52	3. 17
Control vs. fluoride	1	[1] 1. 16	1. 16	3. 74	4. 01
Sex	1	[1] . 01			
Interactions:					
Bone part×fluoride	2	[1] . 23			
Bone part×sex	2	. 77			
Sex×fluoride	1	. 02			
Within groups	57	17. 44	. 31		
Remainder	127	11. 64			

[1] Adjusted for unequal numbers.
[2] Significant at $P<.01$.

found in the literature, and the following approach was therefore devised:

To obtain an overall impression of representative thickness, the compact layer was measured with an ocular micrometer, and the two extremes, for the thickest and the thinnest points were recorded. All measurements were made with the same microscope, 10X ocular, and the lowest power or scanning objective, 5X N.A. 14. A rough calibration would be 1 oculomicrometer unit equals 0.1 mm. The iliac crest could not be measured satisfactorily because of marked irregularity of cortical contour. Hence only the measurements for the vertebra and the rib were used. Measurements of the cortex of the vertebral body adjacent to the hyaline articular cartilage were tabulated separately from those of the cortex of the vertebral body at other points, usually anterior and lateral. Osteoarthritic zones with spur or bridge formation were avoided as far as possible.

Statistical analysis of the measurements revealed no significant differences between the controls and the fluoride series (tables 2 and 3). The average coded measurements (square root of measurements) were 1.734 units for the controls and 1.550 for the fluoride series. The F value attributable to the difference was 3.74, and the theoretical F value with 1 and 57 degrees of freedom was 4.01 at the 5 percent probability level of significance.

Table 4. Cortical and medullary bone changes in persons ingesting fluoride and in controls

Bone changes	Fluoride series		Control series	
	Number bones	Number persons	Number bones	Number persons
Total examined	99	37	94	33
Compact cortical bone				
Architectural abnormalities	4	2	2	1
Excessive active osteoclasia	20	15	15	10
Spongy medullary bone				
Architectural abnormalities	8	5	7	5
Excessive active osteoclasia	18	11	11	7

Figure 4. Increased deposition of osteoid tissue, rib trabeculae, 105X, 71-year-old man, resident 48 years of a community with a natural fluoride level of 4.0 ppm.

The mean measurements for the various bone categories (the lumbar vertebral cortex adjacent to the hyaline articular cartilage, the vertebral cortex elsewhere, and the rib cortex) did, however, differ significantly (tables 2 and 3). The F value attributable to differences in the measurements was 23.52, which is to be compared with the theoretical F value of 3.17. This comparison was independent of the fluoride-control comparison, and an adjustment was made for unequal numbers of bones in the three categories.

Abnormalities in bone architecture, such as irregular or excessive new bone deposition, resorption, excessive cellularity, fibrosis, and increased active osteoclasia were evaluated also. All bones were studied for these conditions.

Focal abnormality in cortical bone architecture was found in 2 bones in 1 control (table 4). Similar focal abnormality was observed in 4 bones in 2 of the fluoride group. An example of one type of abnormality observed, focal increased osteoid deposition, is shown in figure 4.

Active osteoclasia was believed increased slightly (+) in 10 bones, moderately (++) in 3 bones, and severely (+++) in 2 bones from 10 persons in the control series of 94 bones (fig. 5). In the fluoride group of 99 bones, osteoclasia was considered increased slightly (+) in 15 bones, moderately (++) in 4 bones, and severely (+++) in 1 bone from a total of 15 individuals.

Spongy Bone of Medulla

An attempt was made, though admittedly the results are approximations only, to determine trabecular breadth or thickness by ocular micrometer measurement, as was done with the cortex. The two extremes were recorded, and a representative value was tabulated. Abnormalities in bone architecture and evidence of increased osteoclasia were recorded also.

The average coded measurements for the spongy medullary bone are given in table 5. The differences in values between the controls and the fluoride series were not significant when the figures were analyzed statistically. However, as in the cortical bone analysis, a statistical difference was found between the values for the three bone categories.

Among the controls qualitative abnormalities were found in 7 bones in 5 persons (table 4). Focal architectural irregularity was seen in 6 bones, and a small osteoma, in the seventh (fig. 6). Similar focal irregularity in architecture was observed in 8 fluoride-exposed bones in 5 individuals. No tumors were found among the fluoride group.

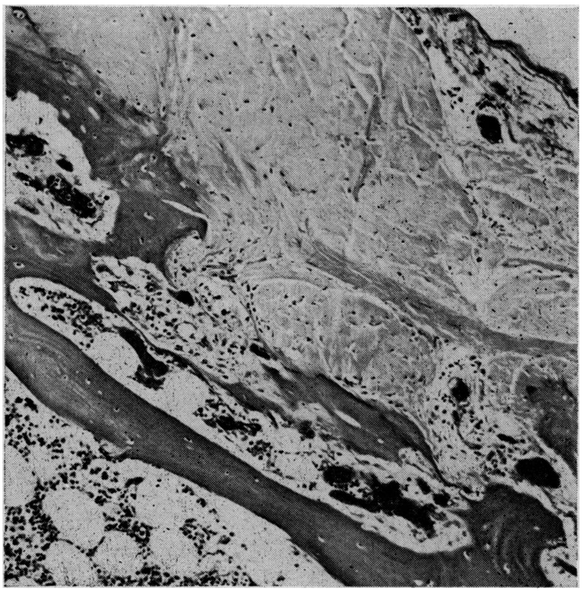

Figure 5. Increased active osteoclasia, vertebral cortex, 105X, 74-year-old man, control series.

Table. 5. Average coded measurements [1] for spongy medullary bone, fluoride and control series

Bone category	Fluoride series	Control series	Both series
All parts	1. 134 (97)	1. 126 (90)	1. 130 (187)
Lumbar vertebra	1. 183 (36)	1. 185 (31)	1. 184 (67)
Iliac crest	1. 215 (32)	1. 264 (26)	1. 237 (58)
Rib	. 984 (29)	. 961 (33)	. 976 (62)

[1] Square root of measurements.

NOTE: Figures in parentheses are numbers of measurements.

Active osteoclasia was believed increased slightly (+) in 11 bones from 7 persons in the control series. In the fluoride group osteoclasia was considered increased slightly (+) in 14 bones, moderately (++) in 3, and severely (+++) in 1 bone from a total of 11 persons (fig. 7). In both groups active osteoclasia was often associated with osteoblastic activity and new bone deposition nearby. Variation in staining characteristics of the intercellular substance, configuration of the cement lines, degree of cellularity, and appearance and arrangement of osteocytes and osteoblasts, as mentioned in the discussion of the cortex, combined to provide fairly reliable impressions concerning relative ages of different bone layers.

Bone Marrow

Most marrow sections of both the fluoride and the control series showed active hematopoiesis. Of 93 satisfactory marrow sections in the control group, 63 were graded +++; 25, ++; 4, +; and 1 was considered atrophic. Interesting qualitative features of the marrow sections from the controls included focal lymphoid hyperplasia (11 sections), focal erythroid hyperplasia (9 sections), and focal myeloid hyperplasia (7 sections). In 3 there was focal

proliferation of megakaryocytes. The marrow of one bone revealed rather extensive fibrosis, and that of another showed focal hyperplasia of eosinphils. There were thus 32 bones with focal qualitative marrow changes.

Of 97 satisfactory marrow sections in the fluoride-exposed group, 69 were graded +++ quantitatively; 23, ++; and 5, +. Comparative qualitative study showed 17 with focal lymphoid hyperplasia, 1 with focal erythroid hyperplasia, and 4 with focal myeloid hyperplasia for a total of 22 qualitative changes.

Intervertebral Lumbar Body Joint

Osteophytosis occurred in both groups in the form of "spurs" or "lips," sometimes bridges (figs. 8 and 9). The osteophytes were composed of irregularly arranged osteoid tissue and mature bone, irregularly calcified cartilage, and fibrous tissue often associated with increased osteoclastic activity (fig. 10). The marrow in the osteophytes was usually fatty and deficient in hematopoietic elements. Accompanying the above process were mixtures of bone, fibrous tissue, and haphazardly calcified cartilage at and near the attachment of the osteophyte to the line of junction between hyaline articular cartilage and cortical bony plate. The normally

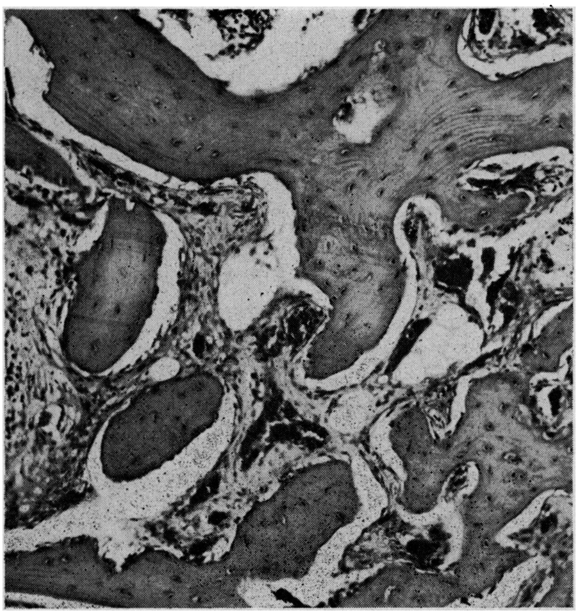

Figure 6. Small osteoma, rib medulla, 105X, 35-year-old man, control series.

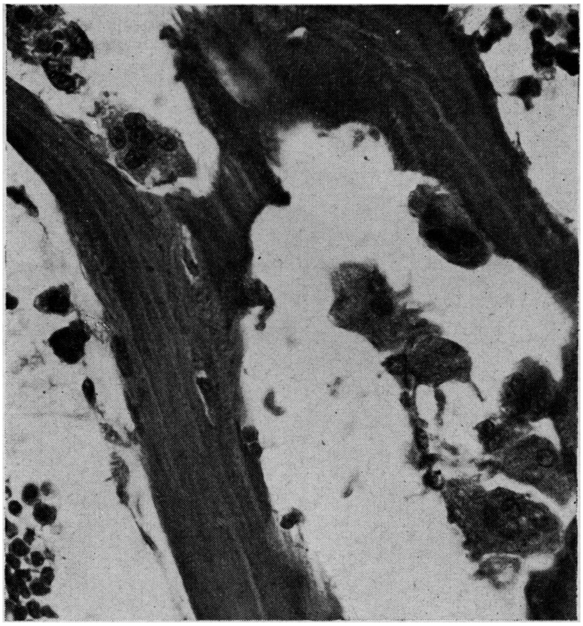

Figure 7. Increased active osteoclasia, trabecula of lumbar vertebra, 415X, 69-year-old woman, resident 28 years of a community with a natural fluoride level of 2.5 ppm.

even contour along this line was usually disrupted. Varying degrees of thickening were noted in the subchondral bone along the line of attachment to the osteophyte. Large osteophytes were often associated with irregularity in appearance of that portion of the annulus fibrosus near the attachment of the osteophyte. Fibrillation, irregularly increased porosity, or cystic degeneration was observed. Clefts in the intervertebral joint matrix were seen in both groups and were impossible to differentiate from artefacts.

The periosteum and anterior longitudinal ligaments over the osteophytic process revealed only nonspecific fibrous thickening.

No inflammatory reaction was noted within the annulus fibrosus or the nucleus pulposus even with advanced osteophytosis. The central portion of the nucleus pulposus was usually porous in the younger subjects (30–39 years) of both groups. In such cases multiple, irregularly shaped, cystic zones were apparent. They contained amorphous eosinophilic material in which occasional viable-appearing cartilage cells could be identified.

The annulus fibrosus in the young patients in

both groups consisted of fairly dense layers of sparsely cellular fibrous tissue. As this tissue approximated the nucleus pulposus, it was arranged in interlacing bands among cartilage cells.

Figure 8. Osteophyte, lumbar vertebral body, 14X, 62-year-old woman, resident 19 years of a community with a natural fluoride level of 2.5 ppm.

Figure 9. Fibrosis and increased osteoclasia in an osteophyte, lumbar vertebral body, 35X, 73-year-old woman, control series.

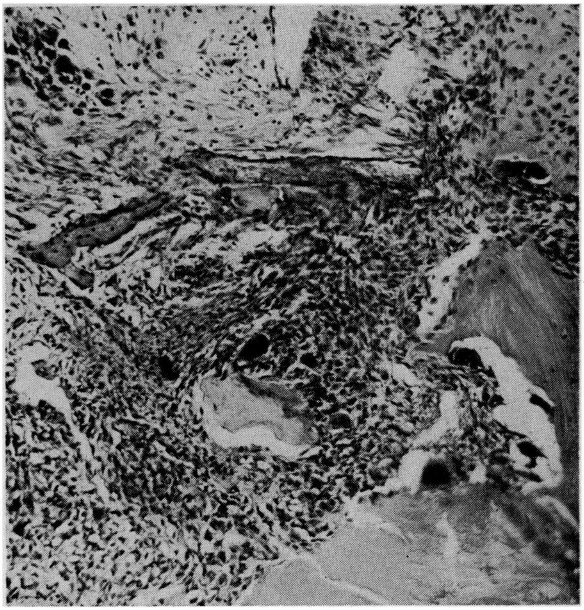

Figure 10. Increased active osteoclasia and fibrosis near osteophyte attachment, 105X, same bone and patient as in figure 9.

Also in the young patients the hyaline articular cartilage blended almost imperceptibly with the loose fibrocartilage or elastic cartilage of the nucleus pulposus and annulus fibrosus. Some variation in thickness was noted in the hyaline articular cartilage. The cartilage cells were arranged more regularly and their nuclei were oriented more nearly in parallel planes than those in the nucleus pulposus or annulus fibrosus. Occasionally, small clefts with loose connective tissue and capillaries penetrated the hyaline cartilage near its line of junction with the subchondral bone. The line of calcification was fairly even along this junction in the young patients, but prongs of cartilage extended beyond into the subchondral bone, and, similarly, microscopic prongs or tongues of bone and osteoid tissue projected upward into the hyaline articular cartilage. The marrow adjacent to the subchondral bone occasionally showed focal proliferation of delicate fibroblastic elements in the young patients of both groups.

In the aged patients of both groups cystic changes in the nucleus pulposus and fibrillar changes in the annulus fibrosus were more prominent. In the annulus near the periosteal junction, fibrosis and proliferation of vascular

Table 6. Changes in lumbar intervertebral body joints

Joint changes	Fluoride series	Control series
Total examined	31	35
Osteophytosis	12	18
Other evidence of osteoarthritis	4	5
Miscellaneous pathology	1	1

channels were sometimes observed. The vascular channels were occasionally arranged in clusters resembling telangiectasia.

Of 31 satisfactory sections of lumbar intervertebral joints from the controls, there were 12 with osteophytosis (table 6). The severity was rated arbitrarily from + to +++. In 6 persons it was graded +++, or severe. In the fluoride group of 35 satisfactory sections, there were 18 with osteophytosis. It was rated severe (+++) in 9. Other evidence of osteoarthritis included irregular proliferation of bone, osteoid tissue, cartilage, and fibrous elements disrupting the even line of junction of hyaline articular cartilage and subchondral bone. This irregularity was apart from that near the attachment of osteophytes described above. Such evidence of osteoarthritis was found in 4 controls and 5 of the fluoride group. Miscellaneous arthritic changes suggestive of trauma and accompanied by distortion of the joint were observed in one person in each series. There was no example in either series of rheumatoid spondylitis.

Discussion

Reports of microscopic bone changes in man after chronic exposure to fluorides are rare. Furthermore, some of the cases reported have been complicated by chronic disease that could have contributed to the changes. Roholm (*2*) reported 2 cases, 1 of which was complicated by a syphilitic infection. The other case occurred in a 68-year-old man exposed to cryolite for 25 years. The findings on gross and microscopic study included calcification of marginal tissues, ligaments, and tendons, increased thickening of the compact bone, irregular granular deposition of calcium in the intercellular substance, osteoid reaction around Haversian systems, and deposition of calcified fibrous tissue. The fluoride level of the bones was as high as 60 times normal values.

Another case, reported by Linsman and McMurray (*3*) and later listed in the Atlas of Orthopedic Pathology (*4*), was complicated by chronic renal disease. This occurred in a 22-year-old white man from a high-fluoride area in Texas. On microscopic examination his bones were described as having large trabeculae and "granular" architecture with lamellae which were irregular, not well seen, and with a tendency to fragmentation. Also described was some "condensation" of bone at the periphery of the trabeculae. The sternum contained 0.69 percent fluoride and the lumbar vertebra 0.75 percent.

In 1937 Bauer, Bishop, and Wolff (*5*) presented the findings in a worker exposed to phosphate rock containing about 4 percent fluoride. At necropsy the chemical concentration of the bones was 10 to 20 times normal fluoride values. The microscopic changes, reported only in a rib, included an increase in width of the cortex and thickening of the trabeculae. These investigators found no young osteoid tissue and no widespread deposits of calcium as described by Roholm. They observed little distortion of the normal bone architecture except reduction in the diameter of the Haversian canals and encroachment upon the marrow.

Weinmann and Sicher (*6*) advanced a tentative theory of the effects of fluorides in older persons and animals: first, there is a slow and incomplete destruction of compact bone and partial transformation into spongy bone; then, fairly dense osteophytes of both immature and mature bone and narrow osteoid seams are laid down as compensatory reinforcement, most prominent near the periosteum.

In our study microscopic changes in ligaments, parosteal tissue, and the periosteum were more numerous in the controls than in the fluoride series. Nothing comparable to Roholm's findings of calcification of marginal tissues, ligaments, and tendon was observed. Focal calcification and cartilaginous changes of the periosteum and adjacent tendon or fascia of the iliac crest were seen with equal frequency

and intensity in both the control and the fluoride groups and were interpreted as normal.

Statistical analysis of measurements of bone mass in the cortex and medulla revealed no significant difference between the controls and the fluoride series. Since the fluoride group was approximately 12 years older than the control group (table 7), the differences in occurrence of osteoclasia and osteophytosis were studied further to determine whether there was any relation to age.

Table 7. Average age (in years) of persons supplying bone and joint specimens for microscopic examination

Sex	Fluoride series	Control series	Both series
Both sexes	67. 8 (37)	55. 6 (33)	62. 0 (70)
Male	64. 5 (17)	54. 0 (24)	57. 3 (41)
Female	70. 5 (20)	60. 0 (9)	67. 2 (29)

NOTE: Figures in parentheses are numbers of persons.

Ten of the 15 bones with increased active osteoclasia in the cortex of the controls were from 6 persons 60 years of age or over. There were 41 bones from 14 subjects in this age category; thus the incidence of increased osteoclasia, by bones, was 24.4 percent. By contrast 16 of the 20 bones with increased cortical osteoclasia in the fluoride series were from 16 persons 60 years of age or over. There were 68 bones from a total of 26 subjects in this age category for an incidence, by bones, of 23.5 percent.

Increased active osteoclasia in the medulla was similarly considered. Eight of the 11 bones of the controls with that finding were from 5 persons 60 years of age or over. Thus, the incidence for the 41 bones from this age category was 19.5 percent. In the fluoride series 17 of the 18 bones with that finding were from 10 persons aged 60 or over. The 68 bones from that age group yielded an incidence of 25.0 percent.

Examination of lumbar intervertebral body joints showed an increase in osteophytosis in the fluoride series. Many roentgenologists and orthopedists feel that osteophytosis in the lumbar vertebrae is not in itself to be considered a manifestation of arthritis or a cause for symptoms or disability (*7*, *8*). Schmörl (*9*) found spinal osteophytes in 90 percent of all women over 60 years of age. On analyzing our data in the light of the difference in average age between the two groups, the difference in incidence of osteophytosis almost disappears. Nine of 13 patients, 69.2 percent, 60 years of age or over among the controls had osteophytosis as compared with 16 of 24, 66.0 percent, in the same age category in the fluoride series.

The differences in incidence of architectural abnormalities were not significant. Bone marrow examinations showed focal qualitative changes of minor importance. They were more frequent in the controls than in the fluoride series.

The results of this study can be correlated to some extent with previous work on necropsy material in Colorado Springs, where the fluoride level is 2.5 ppm (*1*). In that study there was no significant difference in the occurrence of bone cancer between 334 long-term residents (more than 20 years) and 188 short-term residents (less than 5 years). There were 3 deaths attributed to bone cancer in the former group and 2 in the latter. The microscopic study of bones adds further support to the belief that fluoride in drinking water at a level of 1.0 ppm can be ingested without cumulative toxic effect.

Summary

Microscopic examinations were made of 99 bones from 37 persons coming to necropsy who had resided 10 years or more in communities where the drinking water contained 1 to 4 ppm of naturally occurring or artificially added fluoride. Ninety-four bone specimens from 33 controls who had lived in areas where the drinking water contained less than 0.5 ppm fluoride were used for comparison.

In addition to the bone specimens, the lumbar intervertebral body joints of the subjects were examined.

The microscopic examinations showed no significant differences between the fluoride-exposed group and the control group that could be related to fluoride intake. Microscopic changes

in the bones and joints incidental to aging and due to non-fluoride-related conditions were observed in both series.

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Radiation Protection

The New Jersey Legislature has created a Commission on Radiation Protection in the State department of health. The recently approved Radiation Protection Act specifically details the duties and responsibilities of the health department and the newly created commission.

The commission, consisting of five scientifically trained members appointed by the Governor and serving 4-year terms without compensation, will adopt, promulgate, amend, and repeal codes, rules, and regulations that may be necessary to prohibit or prevent unnecessary radiation.

Policies and programs developed by the health department under authority of this act will be reviewed by the commission. The commission, when requested, will also provide the department with technical advice and assistance.

The health department's responsibilities with regard to radiation protection will encompass administration, personnel, program development and evaluation, consultation with interested or affected groups, research, training, and demonstrations, health education and information, review of plans and specifications for the design and shielding of radiation sources, and inspection.

The act requires "all sources of radiation shall be shielded, transported, handled, used, and kept in such manner as to prevent all users thereof and all persons within effective range thereof from being exposed to unnecessary radiation." The health department is empowered to issue orders directing persons to cease and abate causing, allowing, or permitting "unnecessary radiation." In the event of an emergency, the health department has the right to order immediate compliance with codes, rules, and regulations laid down by the commission, and it may bring civil action in the Superior Court to prevent violations of the provisions.

No ordinance, resolution, or regulation concerning unnecessary radiation adopted by any municipality, county, or local board of health can be effective, according to the act, until a certified copy of such ordinance or regulation has been submitted to the commission and approved by the commissioner of the health department.