THE MEDICAL ASPECTS OF WATER FLUORIDATION

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The dental benefits from drinking water containing about 1 part per million (1 ppm = 1 mg/l) of fluoride ion during childhood are well known. The safety of adjusting public supplies of drinking water to this content of fluoride in temperate climates (or to about 0.7 ppm in hotter areas) is universally accepted among reputable professional groups with an interest in the problem of dental caries. The National Research Council, The American Medical Association, The American Dental Association, and The Commission on Chronic Illness, among many others, have taken unequivocal positions in this connection. The American Academy of Pediatrics, in an official resolution on water fluoridation,\(^1\) has approved “the addition of up to approximately 1 part in a million of fluoride to communal water supplies in order to reduce dental caries in the children of our nation.”

The practicing pediatrician who wishes to lend his support in promoting water fluoridation in his own community does not lack sound professional backing or need more evidence on the safety of this procedure. His immediate need is for more specific information to counteract the arguments raised by the increasingly vociferous groups in opposition to this procedure. This paper will, therefore, touch briefly on the dental aspects of water fluoridation, present some background information on the medical aspects of the subject, and analyze some of the arguments raised by the opposition.

Persons who have been continually exposed during childhood to drinking water containing about 1 ppm of fluoride, whether the water contained the fluoride at its natural source or whether its content of fluoride was adjusted to this concentration, are found to have markedly less dental caries and resultant loss of teeth from caries than persons drinking water deficient in fluoride. The rate of decayed, missing, or filled permanent teeth (the DMF rate) is the most frequently used index of the prevalence of dental caries and its end results. Actually, the DMF rate minimizes the possible beneficial effects of preventive measures. Once a tooth shows a carious lesion, even though this might be only a small cavity at the base of a pit or fissure on the occlusal or biting surface of the tooth, that tooth is given the same rating as a tooth lost from advanced dental decay.

Even with the limitations of the DMF rate, however, several studies have shown that children who consistently use water containing fluoride at the desired level show one-half to two-thirds lower DMF rates than comparable groups of children in nearby communities with water deficient in fluoride.\(^2\) The 6- to 9-year-old children in Newburgh, New York, for example, who had been drinking fluoridated water all their lives, had a DMF rate 58% lower than that of a control group of the same age in Kingston, New York.\(^3\) Furthermore, with about the same amount of dental treatment provided to each group, the children in Kingston had already lost about eight times as many first molar teeth from caries as had the children in Newburgh. Of great significance was the fact that the proximal or adjacent surfaces were protected to an even greater degree than the occlusal surfaces. Caries occurring on the proximal surface is much more difficult to detect and treat, and often requires removal of much sound tooth structure prior to placement of a filling.

That dental benefits carry over into adult life is indicated by studies of individuals residing continuously in Colorado Springs, Colorado, where the water supply contains 2.5 ppm of fluoride, and in Boulder, Colo-

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rado, where the water is deficient in fluoride. Among comparable groups of adults aged 20 to 44 years, the DMF rate was about 60% less in Colorado Springs than in Boulder. The adults in Boulder had lost three to four times more teeth from dental caries than the residents of Colorado Springs.

Dental fluorosis, a term applied to a broad range of changes in the enamel due to fluoride ingested prior to 6 to 8 years of age, deserves brief consideration. The questionable to mild stages, consisting of whitish flecks or opaque areas without breaks in the surface of the tooth, are detectable without difficulty only by a trained examiner. These stages are not disfiguring. The moderate to severe stages present brown staining and breaks in the continuity of the surfaces of the teeth. No disfiguring mottling has been observed at levels of fluoride recommended for fluoridation of water. On the other hand, nonspecific white spots on the teeth, or enamel hypoplasias, found in about 20% of the population in areas where water is deficient in fluoride, are greatly reduced among children drinking fluoridated water.3

Trace quantities of fluoride are present in the normal diet in the United States, tea and sea foods containing relatively greater amounts than other foods. Fluoride salts are readily absorbed, even in the presence of large amounts of dietary calcium, in concentrations far greater than that of fluoridated water. Much of the fluoride is rapidly excreted in the urine at a rate directly related to the amount of fluoride consumed. Apart from the teeth, significant deposition of fluoride occurs only in the bones, possibly to the extent of one-quarter to one-half of the amount of ingested fluoride even when concentrations are low. Hodge has indicated that the fluoride ion apparently substitutes for the hydroxyl ion on the surface of the bone crystals without notable biologic disadvantage.5 The process is reversed when ingestion of fluoride ceases. The fluoride is mobilized slowly from the skeleton and excreted in the urine.

The safety of fluoridation of water has been obscured by a failure to differentiate between use of trace quantities of fluoride and exposure to toxic amounts of fluoride in mining and industrial processes or in laboratory investigations. Most of the voluminous literature on the toxicology of fluorides is irrelevant to the present discussion because the quantities of fluoride involved are usually the equivalent of drinking water with concentrations at least 100 to 200 times higher than the levels recommended for prevention of dental caries.

There have been no well-documented reports on nondental effects from water containing even several times the concentration of fluoride recommended for prevention of dental caries. The 10-year study of comparable children in Newburgh and Kingston, New York, failed to show any nondental differences that could be ascribed even remotely to the ingestion of fluoridated water.6 These children were given careful medical histories and physical examinations, supplemented by studies of urine, blood, and roentgenograms. No roentgenographic changes have been found in the bones of adults up to 78 years of age who have been using water containing between 1.2 and 3.0 ppm of fluoride over extended periods of time.7 In an extensive study in Texas adults in Bartlett, exposed to drinking water with 8 ppm of fluoride for an average of 37 years, were compared with adults in the nearby community of Cameron, with a drinking water supply containing 0.4 ppm.8 The rates of disease did not differ significantly in the two groups. A somewhat higher proportion of the group in Bartlett showed questionable or slightly increased bone density on roentgenographic examination, but in no instance were any symptoms or functional changes related to these findings. It should be emphasized that this absence of significant findings occurred in the presence of fluoride levels about eight times greater than recommended for fluoridation of water.

Careful comparison has also been made of the age-adjusted death rates from heart disease, cancer, nephritis, diabetes, and cirrhosis of the liver in cities having varying
levels of fluoride in their water supplies. Even a slight hastening of pathologic processes should have altered the pattern of death rates by age from these various conditions but no differences of statistical significance could be found. Similarly, no difference was observed in the trends of the maternal, fetal and infant mortality rates in Newburgh and Kingston during the 5 years preceding the start of the study and during the 10 years of the study.

As previously indicated, the leading medical, dental and related scientific organizations have expressed a belief in the safety of fluoridation of water. Despite this, the opposition groups have become more vociferous than ever. Their efforts have been successful in many communities in postponing the start of fluoridation and, in some instances, in having fluoridation discontinued after a period of successful operation. The nature of the opposition has changed during the past 6 or 7 years. Whereas formerly there were some conservative scientists who deferred judgment on the safety of water fluoridation until still further evidence should be available, today the opposition is based, with rare exceptions, on emotional grounds.

There can be no effective answer through marshalling of scientific evidence to the purely emotional arguments of those who are threatened by any change. Arguments that fluoridation is an infringement of personal or religious liberty are answered by pointing out that the introduction of measures of ultimate benefit to the entire population without harm to anyone is fully consistent with American tradition. The supreme courts of at least seven states have ruled favorably on the constitutionality of fluoridation, indicating that the procedure is not an infringement on any liberties. The United States Supreme Court has refused on four occasions to review the rulings of the state courts, the last occasion as recent as May, 1956. The argument that fluoridation is mass medication is equally invalid, since fluoridation is simply a preventive measure and no different in principle from the legal requirement in some states that all bread and flour sold in these states be enriched to meet established minimal nutritional levels.

The antifluoridationists have placed increasing reliance on a handful of physicians who have travelled extensively about the United States to appear at hearings and public meetings in opposition to fluoridation. Of these, only Spira has presented any original documented material on possible systemic effects of fluoride-bearing water. He has published a series of papers purporting to show that chronic systemic fluorosis may be manifested by at least 30 different conditions of such diverse natures as Riehl's melanosis, otosclerosis, varicose veins, and stammering. Cox has disposed of the validity of the relationship of these conditions to fluoride by showing that Spira, with one exception, had no knowledge of the fluoride content of the water consumed by these patients. In the one case in which this was known, the fluoride level of the water was 0.15 ppm, a negligible amount. Spira apparently used as evidence for his diagnosis of systemic fluorosis the presence of enamel hypoplasias which, as previously shown, are found in about 20% of persons not exposed to fluoride-bearing water.

The opposition refers extensively to studies made in India, China, and other countries on the presumed systemic effects of fluoride-bearing water. The most prominent clinical feature of the reported cases has been stiffness of the spine as a result of calcification of the adjacent soft parts and hyperostoses of the spine itself. Most of these reports are from exceedingly hot areas with very high concentrations of fluoride in the water. The supposed systemic effects of fluoride cannot be separated from the effects of malnutrition, of other prevalent pathologic conditions, and of generally poor hygienic conditions. The drinking of large quantities of tea of variable fluoride content further complicates the picture. Above all, it is common practice in these areas to use large amounts of salt made by evaporation of sea water, adding significant amounts of fluoride to the diet. In a word, none of
these reports can be cited as evidence bearing on the safety of water fluoridation.

No instances of stiff back from fluoride-bearing water, even at higher concentrations of fluoride have been reported from the United States or Canada, though widespread interest in the subject should have brought such cases to attention. However, two papers on related subjects, frequently cited by the opposition, deserve some consideration. The first of these contains a passing reference to rickets among children receiving fluoride in drinking water in a discussion of mottled enamel by Lemmon in 1934. The following quotation is the full reference to rickets in this paper:

"Some of these babies have more tendency to bowing of the legs, even in the face of constant antirachitic therapy, thus supporting the theory that the toxic fluorides interfere with the bone and dental metabolism."

While they cite this clinical impression uncritically with approval, the opponents neglect the carefully controlled evidence from the Newburgh-Kingston study, based on annual physical and roentgenographic examination.

The other paper describes a case diagnosed as osteosclerosis from fluoride in drinking water. The opponents variously refer to this case as a death due to fluorosis, as a death with fluorosis, or as a case of anemia due to encroachment on the bone marrow by sclerotic bone. The actual situation, from an analysis of the paper and related evidence, appears to be quite different. The patient was a 22-year-old white soldier who was first seen in the military hospital because of a chalazion. A moderate degree of mottled enamel was noted at the time of admission. After aspiration of sternal marrow, performed because of an intractable anemia, the marrow became infected and the patient's condition was noted to be serious and the presence of severe renal insufficiency was discovered. Roentgenograms revealed increased density in the lower ribs, lumbar spine and pelvis, with almost complete obliteration of the trabecular pattern. The patient died shortly thereafter in uremia. The patient had lived until 7 years of age in Spur, Texas. This community, according to the original paper, had a fluoride level of 12 ppm, but this was later corrected to 1.2 ppm. The actual fluoride level of this community has been about 2.4 ppm, according to recent information.

Necropsy showed almost total destruction of the renal parenchyma, the right kidney consisting of a cystic mass with a thin shell and the left kidney being very small and contracted. The origin of the renal lesions was not clear, but it was obvious that chronic renal insufficiency had been present. One parathyroid gland was found and grossly appeared slightly enlarged. Chemical analysis of the sternum and a lumbar vertebra showed a high fluoride content, whereas analysis of bone from a "normal control" showed no fluoride. A portion of the patient's pubic bone showed a higher specific gravity than a "control" specimen.

The bone changes in this case were more likely part of the picture of renal hyperparathyroidism secondary to severe, chronic renal insufficiency, than a manifestation of fluorosis. No symptoms were attributed to the osseous findings. The authors themselves state that the anemia could not have been due to mechanical encroachment on the bone marrow and was probably secondary to the uremic state. There is considerable doubt about the reliability of the determination of the content of fluoride in the bones since no fluoride was reported in the normal controls; normal bones should have detectable amounts. The specific gravity of the bone, according to the authors themselves, is not in agreement with earlier findings in fluoride osteosclerosis among cryolite miners. The grounds for the diagnosis of the sole reported case of fluoride osteosclerosis from drinking water in the United States are, therefore, open to very serious question.

The opponents often raise the question of the possible effect of variation in intake
of fluid in the production of toxic effects from fluoridated water. The implication is that certain individuals who ordinarily drink more water than others or who may develop polydipsia from diabetes mellitus are in great danger of toxicity. Such fear has no basis in fact. The margin of safety for non-dental effects is far greater than any possible increase in intake of fluid for short or long periods of time. Furthermore, there is no evidence that disfiguring dental fluorosis will occur in such individuals. The lower concentration of fluoride of about 0.7 ppm recommended for hot climates has already been mentioned as an additional safeguard. The point is that the recommended levels of fluoridation have been based on extensive experience with large population groups. No disfiguring mottled enamel has been found in any children in the long-term studies, and the groups examined undoubtedly included children with extremes in water intake. The fluoride level used in water fluoridation is not necessarily the optimum for the prevention of dental caries in all children. Rather, it is the most favorable level for significant prevention of dental caries in the greatest number of children without danger of any undesirable effects in any of the children.

The allegation that discoloration of teeth of children drinking fluoridated water appears with advancing age is also without foundation. In moderate and severe dental fluorosis there are breaks in the continuity of the enamel and it is in these breaks that disfiguring stains develop. Such breaks are not found in the questionable to mild stages in dental fluorosis present in a small proportion of children receiving fluoridated water. No disfiguring fluorosis was found among these children, nor is there any likelihood of discoloration developing later in life in the presence of unbroken surfaces of enamel.

Other methods of preventing dental caries without resorting to fluoridation of water have been suggested by the opposition. Among these are the application of sodium fluoride solution to the teeth, the use of fluoride tablets, and fluoridation of milk and other foods. The topical use of sodium fluoride solution has a useful role in areas in which water fluoridation is not practicable and during the first 4 or 5 years after initiation of water fluoridation in a community. However, topical application is less effective, and far more expensive and demanding of dental manpower, than fluoridation of water. Fluoride-containing pills may be practicable in carefully controlled situations, as pediatricians know from experience in prophylaxis with penicillin in children who have had rheumatic fever, getting parents to maintain a prolonged daily schedule is often difficult, indeed. To have an entire community carry out such a schedule properly presents extreme difficulties. Other methods, such as addition of fluoride to milk, have not been tested and present obviously great administrative difficulties.

**SUMMARY**

Fluoridation of water is the process of adjusting the concentration of fluoride ion in fluoride-deficient water supplies to a level of about 1 ppm. Groups of children drinking fluoridated water have only about one-third as much dental caries as otherwise comparable groups receiving water deficient in fluoride. These benefits should carry over into adult life, on the basis of evidence from communities in which the fluoride ion is found naturally in the water supply.

Water fluoridation is universally accepted among reputable professional groups. Extensive American studies, made in areas with fluoridated water or with natural fluoride-bearing water having the same content of fluoride, have disclosed no harmful systemic effects to any individuals or groups in the population. No disfiguring dental fluorosis has been encountered among individuals drinking such water. On the contrary, the prevalence of nonspecific enamel hypoplasias has been reduced in such groups.

No well-documented evidence or valid arguments have been presented by the
 vociferous groups opposed to fluoridation of water. Much confusion has been engendered by the failure of these groups to differentiate between the trace quantities of fluoride used in fluoridation and the vastly greater toxic quantities encountered in some mining and industrial operations and in laboratory investigations.

REFERENCES

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