Monitoring of environmental pollutants using dental enamel

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Dental enamel remains essentially inert after its initial formation. Thus, it can provide a permanent and cumulative record of elements in the environment to which the tooth was exposed. This record includes the concentrations of trace elements incorporated into the crystal structure of enamel during its formation. For humans, calcification of teeth begins 4 months in utero and continues for the first 2 decades of life. In addition, there is a record of those elements absorbed by dental enamel, through its microscopic porosity, during the lifetime of the individual.

There is intrinsic scientific value in having the concentrations of trace elements in dental enamel updated by modern techniques. There is also a practical value, however, in that the relationship between environmental pollutants and diseases can be better studied if this updated data is available. For example, such data would facilitate the investigation of any link between the presence of geologically derived elements, such as uranium and the heavy metals, and the incidence of multiple sclerosis. Presently, elemental analyses are underway in this laboratory using fission track analysis, neutron activation, electron microprobe analysis, and inductively coupled plasma atomic emission spectroscopy.

Of all living tissues in the body only dental enamel retains indefinitely the history of its radiation exposure. The effect of radiation on the crystalline hydroxyapatite in dental enamel is to produce free electrons that become trapped indefinitely in defects within the crystal lattice. These free radicals can be detected using electron spin resonance (ESR). A similar technique is used in geological dating.

Knowledge of the cumulative absorbed radiation dose in the general population, and in populations suspected of having been exposed to large doses of ionizing radiation, can lead to a direct measure of radiation risk. Also, for acute radiation accidents dosimetry using dental enamel can provide a means of triage, or it can be of forensic value in post-mortem investigations. ESR in dental enamel has been successfully used to study doses absorbed by victims of acute radiation exposures such as that resulting from the Chernobyl nuclear disaster and the participation in atomic bomb tests. Further, a means of separating contributions to the overall dose to a tooth from diagnostic and background radiation has been developed.

The ESR technique utilizes dental enamel obtained from teeth extracted in the normal course of dental treatment. A lack of sensitivity, and formidable problems in miniaturization of the large laboratory equipment used for the measurement, makes in-vivo ESR measurements of dental enamel unattainable at present. Even with existing limitations, teeth provide unique advantages for both concurrent and retrospective monitoring of pollutants.

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