Chapter 2

Human Teeth as an Indicator for Heavy Elements in Body

Introduction

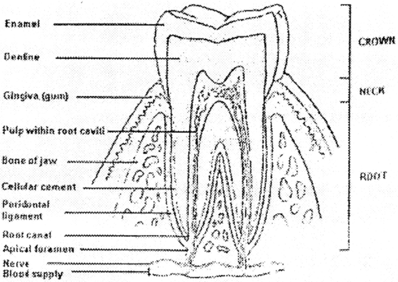
We are living in an environment surrounded by toxic elements. Our body is exposed to these chemicals at the level that could affect our human biochemistry. Although our body has mechanisms for transforming and eliminating many of these toxic elements we encountered over our lifetime, these safety mechanisms may be inadequate or even inappropriate in our modern society.

Some chemicals are capable of subtle yet insidious health effects, especially in children. The metals such as lead, mercury, arsenic, aluminium, cadmium, zinc and manganese, which are often accumulated in certain organs and can have adverse effects on the physiology of those organs.

Human tooth compartments would appear to be suitable indicator of these heavy metals in long-term exposure (K.Griinke et.al., 1996). Recent studies by several groups have showed that human teeth are amenable to both in vivo and in vitro determination including by x-ray fluorescence spectroscopy (Zaichick and Ovchjarenko, 1998; Zaichick et al, 1999; Bloch et al, 1998)

Human tooth is not a homogeneous entity but consists of three major parts. They are enamel, dentine and pulp. Calcium, phosphate carbonate, magnesium and sodium are the major inorganic components of teeth. Teeth also accommodate organic matter and several other important trace elements such as lead, cadmium and zinc.

2.1 The Effects of Pb on Human Health



Lead (Pb) poisoning is a health hazard to adult living in the urban environment. Excessive lead exposure causes permanent neurological scratch to the development of central nervous system, i.e. affect neurotransmission, altering the output and utilization of the brain chemicals such as dopamine, serotonin, and GABA (Gamma-aminobutyric acid) that control behavior and emotions especially in young children. The toxicity of this metal can also bring attention paucity, behavioral clutter, lowered I.Q., poor hand-eye coordination and low vocabulary and reading skills. Physical symptoms of towering lead in both children and adults can be abdominal pain, irritability, constipation, and lack of hunger. In worsening case of lead poisoning, a person may undergo bone pain, gout, arthritis, anemia, memory loss, and numbness or tingling in the extremities.

Lead is also known to be deleterious to humans at blood-lead concentrations exceeding 0.3 ppm and 0.4 ppm in children and adults respectively (T Al-Naimi et.al., 1980). However, the blood lead concentration and the appropriate porphyrin concentration gives only information on the circulating lead in the body at the time of measurement but yields little information concerning the total lead exposure that the individual has received. These limitations in blood chemistry are due to the short-lived existence of the lead in the blood and its rapid confiscation or elimination by other tissues. Needleman, Tuncay and Shapiro (1972) have validated that both primary and permanent teeth sequester lead. Further, the lead stowed in a tooth is permanent and related to the quantity of ingested lead. Shapiro, Mitchell, Davidson and Katz (1975) also had shown the urbanization increased the higher lead exposure.

2.2 The Effects of Cadmium

Cadmium is an important toxic environment pollutant and represents an increasing health hazard to man (Friberg et al, 1974). We couldn't escape from this toxic element because of the diffuse spread of cadmium in food, water and air. These environments worsen under the fast development of industrialization. For persons not exposed occupationally, intake from food and by inhaling cigarette smoke (Ellis et al, 1979) are the most important contributions to exposure. About 5% of the cadmium in the food intake are absorbed. This value can be higher if the person suffers from lack of calcium (Kjellström and Nordberg, 1978). When cadmium is inhaled, 10-40% is absorbed depending on the particle size of the cadmium dust (Friberg et al, 1974). For persons not exposed occupationally, the liver and the kidney (mainly the cortex) contain about 50% of the total body burden (Lars Ahlgren and Sören Mattson, 1980).

A study, which had been carried in Sweden, found the cadmium concentration in the kidney cortex to be about 20 $\mu g\ g^{-1}$ for smokers and 10 $\mu g\ g^{-1}$ for non-smokers and about 1 $\mu g\ g^{-1}$ in the liver. The biological half-life of cadmium in the kidney has been estimated in between of 6-38 years (Kjellström and Nordberg, 1978; Elinder et al, 1976).

For those people who have been heavily exposed to cadmium-containing dust or fumes, concentrations as high as 500 $\mu g\ g^{-1}$ in the liver and in the kidney cortex have been reported (Friberg et al, 1974). When the exposure increases, a larger portion of the cadmium will be found in the liver (Kjellström and Nordberg, 1978). Friberg et al (1974) also found the correlation between the total body burden and the cadmium concentration in urine and blood is poor. However, to estimate the total body burden, it is important to be able to measure directly the cadmium concentration in these organs, which show the highest concentrations due to high uptake and / or slow excretion rates.

Accumulation of low levels of cadmium is tolerated by the body. However, long term chronic exposure may lead to kidney dysfunction.

2.3 The Significance of Calcium (Ca) to Human Health

Calcium is the fifth most abundant element in the human body and the most common of the mineral ions. Table 2.1 showed the elemental composition of the human body.

Table 2.1: The Elemental Composition of the Human Body (Lehninger, 1975)

Element	% Total no. of atoms	Weight (%)
H	63.0	10.0
O	25.5	64.5
C	9.5	18.0
N	1.4	3.1
Ca	0.31	1.96
P	0.22	1.08
Cl	0.08	0.45
K	0.06	0.37
S	0.05	0.25
Na	0.03	0.11
Mg	0.01	0.04

Calcium is the most important structural element, functioning not only in combination with phosphate in **bone and teeth** but also with phospholipids and proteins in cell membranes where it plays a vital role in the maintenance of membrane integrity and in controlling the permeability of the membrane to many ions including calcium itself. Table 2.2 showed the distribution of calcium in a 70-kg man.

Table 2.2: Distribution of Calcium in a 70-kg Man (Nordin, 1976)

Site	Calcium (g)	Weight (%)
Skeleton	1355	98.90
Teeth	7	0.51
Soft Tissues	7	0.51
Plasma	0.35	0.026
Extravascular fluid	0.70	0.052

Besides, Ca is also widely involved in many physiological and biochemical processes throughout the body including the coagulation of blood, the coupling of muscle excitation and contraction, the regulation of nerve excitability, the motility of spermatozoa, the fertilization of ova, cell reproduction, the control of many enzyme reactions and the transmission of many hormone actions at the appropriate receptor site on the cell membrane (Nordin. EC, 1988)

The deficiency or excess amounts of calcium in our body, both could bring the problems to our health; for instance, deficiency of calcium will affect our bone density and thus increase the risk of osteoporosis. However, the adverse effects of calcium in excess amounts could bring the problems of constipation, kidney stones and poor kidney function. It may also interfere with the absorption of other minerals, such as iron and zinc (The American Dietetic Association).

2.4 The Significance of Magnesium in Human Body

Magnesium is the second element only to potassium in terms of concentration in the body's cells. It is involved in many cellular processes, including over 300 enzymatic reactions. Magnesium also is an important factor in bone health, whereas magnesium's combined local and systemic effects that make it an important mineral for proper bone metabolism. 60% of magnesium is found within bone and is incorporated as a minor element in apatite crystals and thus, contributes to bone structure. Besides, magnesium's ability also involved in the regulation of the body calcium.

Magnesium deficit is normally associated with hypoparathyroidism, low production of vitamin D metabolites, particularly 1,25(OH)2D3 and resistance to PTH and vitamin D, resulting in impaired bone metabolism.

Since the structure of bone and teeth are in similar form, the concentration and relationship of magnesium with calcium could be studied throughout this experiment.

2.5 Zinc Important Element in Adolescent Growth of Teeth

Zinc is in every cell of the body and is involved in more enzymatic reactions than any other mineral in the body. High concentrations of this mineral can be found in the skin, liver, pancreas, retina, prostate, teeth and bone. Although severe zinc deficiency is quite rare, marginal deficiency, as may be seen in the elderly and / or vegetarians. Zinc like magnesium, is involved in many cellular processes, one of which is the proper calcification of bone and teeth, especially during the adolescent growth spurt when bone and teeth growth. Zinc's importance in bone metabolism has also been shown to manifest itself during later stages of life.

2.6 Copper in the Role of Normal Development and Bone Maintenance

Copper is the third most abundant trace element in the body, after iron and zinc. 70 to 80 mg of copper in the human body with approximately 19% found within the skeleton. Copper plays an important role in the normal development and maintenance of bone because of its incorporation in the enzyme lysyl oxidase. This enzyme is necessary in the bonding of collagen molecules to one another. Collagen is a protein that impacts strength and flexibility to bone and teeth but to do this it must be properly bonded to other collagen units.

A copper deficiency is associated with poor collagen integrity that may manifest itself as bone abnormalities including osteoporosis. Others have contributed copper's ability to spare bone tissue to its inhibitory effects on osteoblast / osteoclast cell activity. Both of these cells play key roles in bone building and degradation respectively.

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