

REVIEWS

LEAD IN HUMAN TEETH

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ABSTRACT

Lead (Pb) is a heavy metal distributed in the environment linked to a number of adverse biological effects. The teeth of all humans contain certain amounts of lead.

Teeth with elevated levels of lead are usually affected by dental caries and periodontal problems. The highest amount of this metal is located on the tooth surfaces and decreases rapidly with the increase in depth. The highest Pb levels are observed on the palatal surface next to the gums. The lowest values are established on the vestibular side near the cutting edge of the tooth. The concentration of Pb is higher in the tips of the unerupted roots of the deciduous teeth. During the physiological process of resorption of the roots of deciduous teeth, the periapical area may be saturated with this heavy metal.

Lead in saliva leads to an imbalance in the oral microbial colonisation. Higher numbers of *Salivallis lactobacilli* and *Mutans streptococci* colonies in saliva correspond to elevated levels of Pb in teeth.

As age increases, so does the amount of the metal in the teeth, especially over the age of 51. The amount of Pb in the dentin can help determine the age in forensic medicine. There is a clear increase in Pb concentrations in the presence of amalgam obturations and in smokers.

Hard dental tissues are valuable for the study of environmental Pb contamination. Isotopic data of Pb in the dentin provide useful information to identify native or foreign status and assess the geographic place of origin of unidentified human remains.

Keywords: lead, teeth, distribution, heavy metal, dental diseases

INTRODUCTION

Lead (Pb) is a metal distributed in the environment associated with a wide range of adverse health effects. It gets into the body by ingestion, inhalation, absorption through the skin, and affects the whole organism (1). Natural reservoirs of Pb are bones and teeth, and a process of calcium replacement by Pb takes place (2). High concentrations of Pb damage the nerves, kidneys, have carcinogenic effects, cause headaches, arthralgia, lack of interest in study, abdominal cramps, sleep disturbances, daytime sleepiness, and delayed puberty (3,4,5,6). Studies have found that even at minimal levels, Pb can cause adverse mental health effects, schizophrenia, Alzheimer's and Parkinson's disease (7). Prolonged exposure can lead to Pb bioaccumulation and saturnism (8). It

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is expressed by nervous disorders and deposition in the form of a dark grey or green-black streak of lead sulphide on the gums. In chronic poisoning, the circulatory organs are damaged; certain enzymes and endocrine glands are affected. Doses of 0.2–0.3 mg/kg of Pb compounds are sufficient for intoxication. There is a danger of poisoning when painting with lead paints, when using bright-coloured food containers, and breathing gas mixtures coming from car exhausts. Lead is present in cigarette smoke, in some batteries (9), in pipes and in food grown in soils with high Pb content (10).

There is an average of 120 mg of Pb in the human body (11). The body (12) absorbs the metal very well. About 1% of Pb is stored into the bones. The remaining amount is eliminated through urine and faeces.

Methods used for analysis of Pb concentration are inductively coupled plasma mass spectrometry, electrochemical methods, atomic absorption spectrometry, and X-ray fluorescence spectroscopy. Tissues most commonly used for analysis are blood, bone, urine, hair, nails, saliva, and teeth. Biomarkers are not representative for early diagnostics of health damage engendered by Pb. The most appropriate biomarker for determining metal exposure is establishing its levels in the blood (3). Lead levels in the saliva and teeth are comparable (13,14,15). Saliva is not appropriate for evaluating exposure to this heavy metal (16).

Dental changes occur over time. The mineral substance of teeth increases with age and the organic diminishes. The teeth become more brittle and amenable to fracture (17, 18). It is difficult to draw a precise line between the pathological and physiological changes (19). Different chemical substances, medication, and physical factors can affect teeth throughout life (18).

AIM

The aim of this article is to provide scientific data on the concentration of Pb in human teeth and its relationship with various factors.

MATERIAL AND METHODS

We searched PubMed articles, Google, and the available literature.

RESULTS AND DISCUSSION

Dental Diseases

Enamel, dentin, and saliva of all humans contain a perceptible quantity of Pb, and its levels increase with the increase of the caries severity, indicating the caries-causing potential of the metal (15). Dental hard tissues acquire Pb during their formation and those with higher levels are usually more often with damage like caries (20,21). The risk of tooth decay and the need for dental obturation are greater in deciduous teeth of individuals with elevated blood Pb levels (14). Lead poisoning reduces salivary flow, interferes with fluoride activity, and increases the demineralisation of the tooth enamel (22).

A total of 220 teeth were analysed in Spain after digestion by atomic absorption spectrometry. The samples were divided according to age, sex, tooth number, extraction reason, and place of residence. The overall value was 10.36 µg/g of tooth. High concentrations of Pb were found in teeth with pathology, especially with periodontal problems, finding an association between Pb levels and dental disease. This study found that decayed teeth did not show elevated Pb levels (23).

Cumulative Pb exposition is linked with an increased likelihood of tooth extraction. Individuals with higher metal levels have fewer of their own teeth available (24).

Distribution in Teeth

Purchase NG et al. examined samples from different parts of permanent teeth and their Pb levels. Very high Pb content (500–3400 µg/g) and others trace elements – metals (Cd, Zn, Cu, Fe), were found on the external border of the teeth, with the amount quickly decreasing in a few micrometers into the tooth depth (25). The surface of the tooth can be useful as a characteristic of past Pb contact (26). Lead levels in incisor enamel vary with tooth position. The top levels occur on the lingual part near the gingiva and the lowest levels – on the vestibular part next to the cutting edge. The Pb level ratio in enamel to dentin and periapical dentin was 1:2:6. In dentin, the levels were notable in root dentin.

When comparing by tooth group, total Pb become less in the following sequence: first molars, middle incisors, lateral incisors, canines, premolars,

posterior molars, and finally – wisdom teeth. This order corresponds to the period of tooth formation (25).

Results from a 2004 study showed that the concentration of Pb in deciduous teeth of the 10- to 13-year-old group (7.7 µg/g) was greater than that of younger children. The heavy metal concentration was with greater levels in girls – 7.3 µg/g compared to 6.3 micrograms/g in boys. The teeth of the upper jaw had higher Pb concentrations compared to teeth of the lower jaw, and deciduous canines were with the highest metal amount, followed by incisors and masticatory teeth. The results of this study showed that age, sex, and location of growth were not associated with Pb concentration in deciduous teeth (27).

Attramadal A et al. found that Pb content in deciduous teeth was greater than in permanent ones (28). Conversely, other studies found that permanent teeth had greater Pb levels (13 µg/g) than deciduous ones (3.96 µg/g) (23).

About 2/3 of the amount of Pb in the enamel during leaded gasoline use are attributed to it, and the rest is of another origin (paint, lake sediment) (4,14).

A 2006 study demonstrated a methodology in which the spatial spread of Pb in the dentin of deciduous teeth can be used to obtain data on the timing of environmental metal set-out during the pre- or neonatal period. Mean Pb levels in the dentin range from 0.17 to 5.6 micrograms/g, and Pb levels in the enamel range from 0.04 to 1.5 micrograms/g (13).

Lead concentrations in crown dentin and enamel have been studied most frequently, but there is limited information about Pb levels in root dentin or cementum. A 2004 investigation examined the spread of Pb in twenty-six roots of sixteen maxillary deciduous teeth from 7 patients. The Pb amount in roots was 1.67 µg/g. In all samples, higher concentrations of Pb were reported in the apical part of unresorbed roots of deciduous teeth. During the physiological process of resorption of the roots of deciduous teeth, the periapical area may be saturated with this heavy metal (29).

Different studies show varying levels of Pb in teeth (Table 1).

Oral Environment

Lead in saliva makes an imbalance in the oral microbial colonisation. Salivary pH diminishes, oral

Table 1. Pb levels measured in teeth.

Tissue	Quantity (µg/g)	Method	Year	Reference №
Root dentin	1.67 ± 1.43	n.a.	2004	29
Teeth	28.91	Atomic absorption spectrometry	2006	34
Smokers	31.89	Atomic absorption spectrometry	2006	34
Non-Smokers	24.07	Atomic absorption spectrometry	2006	34
With amalgam	31.02	Atomic absorption spectrometry	2006	34
Without amalgam	26.87	Atomic absorption spectrometry	2006	34
Surface of enamel	500-3400	Carbon furnace atomic absorption spectrometry	1986	25
Teeth	1.7–40.5 Median of 9.8	Atomic emission spectroscopy with inductively coupled argon plasma	2000	35
Dentin	0.17-5.60	laser ablation – inductively coupled plasma mass spectrometry	2006	13
Enamel	0.04–1.47	Laser ablation – inductively coupled plasma mass spectrometry	2006	13
Deciduous teeth	7.7	Graphite furnace atomic absorption spectrophotometry	2004	27
Dentin	5.6–6.8	Atomic absorption spectrometry	2010	32
Teeth	10.36	Atomic absorption spectrometry	1994	31

parameters change, the mineralization process is slowed, most often we observe periodontitis, mucosal lesions, enamel defects, fluorosis, and tooth loss (30). Gil F et al. found that higher numbers of *Salivallis lactobacilli* and *Mutans streptococci* colonies in saliva corresponded to higher levels of lead in teeth (31).

Age

All studies agree that with advancing age, the amount of lead in teeth increases, and most of them find a significant increase in levels. Permanent teeth had higher Pb levels (13 µg/g) than deciduous teeth (4 µg/g) (23) in most studies.

A strong correlation among dentin Pb levels and age was found by atomic absorption spectrophotometry in 398 permanent teeth in Kuwait. Dentin Pb accumulation was higher in males compared to females (6.8 vs 5.6). An algorithm was elaborated to establish the age from Pb levels in teeth ($\text{age} = 1.2 \times \text{dentin lead} + 17.6$). This algorithm is applicable only to Kuwait citizens and can be applied when investigating human remains. Similar calculations can be worked out by investigations of dentin Pb values in different regions (32).

Higher Pb concentrations in older adults are related to elevated Pb content in petrol in the past (33). Mean Pb concentrations did not vary significantly in ages 20–50 years, but increased greatly in subjects older than 51 years (34).

Residence, Occupation and Other Factors

People living in urban areas have the highest amount of Pb in their teeth (23), and children living in rural areas have the lowest (25). In 2001 and 2010, people living in areas with higher car traffic were found to have higher Pb levels (4,14).

Inductively coupled plasma-argon atomic emission spectroscopy was used to determine the levels of Pb, Cu, and Zn in forty-seven extracted teeth. Lead values varied from 1.7 to 40.5 µg/g. Higher values were found in six lorry drivers included in the study (35). Studies have shown the ubiquitous presence of Pb throughout the atmosphere (27). Hard dental structures are valuable for the investigation of environmental Pb contamination (33).

Evidence has been presented that the periapical dentin of deciduous dental hard tissues can serve as an indicator of childhood Pb exposure. The variation between the teeth of the same child is negligible (36).

The purpose of the 2006 investigation was to measure Pb and cadmium concentrations in hard dental tissues and the factors that affect them. A total of 268 teeth from people living in diverse parts of Jordan were measured using atomic absorption spectrometry. The average Pb concentrations were 28.91 µg/g. The outcome showed relationship between Pb concentrations and amalgam obturations, smoking, and place of residence. The Pb concentrations in the teeth of smokers (31 µg/g) were higher compared to those of non-smokers (24 µg/g). The Pb concentrations in the teeth of patients with amalgam obturations (31 µg/g) were elevated compared to those without (26 µg/g). Results showed that daily toothbrushing with toothpaste did not reduce Pb values (34).

Isotopic investigations of Pb of Bulgarian teeth give evidence on the origin, migration, and diet of the individual. Isotopes of oxygen, carbon, Pb, and strontium give useful data for identifying native or foreign status and estimating the geographic place of growth of remains in forensics (37).

CONCLUSION

Lead is a heavy metal distributed in the environment linked to a number of adverse biological effects. The teeth of all humans contain certain Pb amounts.

Teeth with elevated Pb levels are usually affected by dental caries and periodontal problems. The highest levels of this metal are measured on the surface of teeth, with the amount decreasing rapidly with depth. The highest Pb levels occur on the palatal surface next to the gums. The lowest levels are established on the vestibular side near the cutting edge of the tooth. The concentration of Pb is higher in the tips of the unerupted roots of the deciduous teeth. During the physiological process of resorption of the roots of deciduous teeth, the periapical area may be saturated with this heavy metal.

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