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Elevated Dentine Lead Levels in Adult Teeth of First Nation People from an Isolated Region of Northern Ontario, Canada

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Lead is neither essential nor beneficial to living organisms, being a toxin that adversely affects humans exposed to it, even at low doses (USCDC 1991). In the past, lead was present in a variety of environmental media, such as food, drinking water, air, soil/dust, and consumer products. In the last two decades, lead levels in the different environmental media have been decreased or eliminated in North America (USCDC 1991). However, a significant source of environmental lead exposure still exists in the form of lead shot used in hunting (e.g. Tsuji and Nieboer 1997).

Two criteria commonly used to assess lead levels in humans are blood and tooth lead concentrations. Because elevations in blood lead are transitory reflecting only recent exposure of one to two months and other types of samples, such as, hair and nail risk external contamination, the study of dentine lead levels in human teeth has become more popular (e.g., Shapiro et al. 1972; Bercovitz et al. 1993). Since lead is deposited permanently in dentine of teeth, analysis of lead content in dentine can be used as an indicator of chronic lead exposure in humans (Bercovitz et al. 1993).

In the western James Bay region of northern Ontario, Canada, all communities are fly-in with no road access. In the most industrialized town of the region, Moosonee, water and soil lead levels have been found to be very low and not of importance as an environmental exposure factor for humans (OMHE 1989). Similarily, air lead levels have been found to be well below the Ontario Ambient Quality Criterion of 5 $\mu g/m^3$ (OMHE 1989). Only two possible sources of environmental lead exposure have been identified for people of this region: white lead used in boat repairs and lead shot contaminated wildmeats (OMHE 1989; Smith 1995; Tsuji and Nieboer 1997). White lead is an unlikely source with only small quantities being sold in the region (Smith 1995). In addition, white lead users are aware of the required safety procedures (Smith 1995).

In this paper, lead levels in teeth collected from adults of Fort Albany, Ontario (western James Bay region) were compared to lead levels found in other

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studies. We also examined the relationship between dentine lead level and age, and whether tooth lead concentrations were at background levels or at levels that warrant concern with respect to environmental lead exposure.

MATERIAL AND METHODS

Adult teeth were collected during the period June 1989 to August 1995, at James Bay General Hospital (Fort Albany Wing: 52.15 N; 81.35 W) from patients (age range: 16-84 years) who for periodontal or carious reasons needed their teeth extracted. A total of 132 teeth were collected from 89 individuals, 54 males and 35 females. Twenty-eight individuals contributed more than one tooth with one person contributing five teeth.

Immediately after extraction teeth were placed in a 5% formaldehyde solution and left overnight. Connective tissue was removed from the teeth the next day using stainless steel currettes. After washing in distilled water, teeth were air-dried prior to being placed in individually marked paper envelopes for storage. Samples containing carious teeth were used since lead content of teeth are independent of the degree of caries (Mackie et al. 1977; Paterson et al. 1988). Restored teeth were also included in the sample because lead levels in restored teeth have been found not to be significantly different than virgin teeth (Paterson et al. 1988). Moreover, none of the teeth collected in this study exhibited root caries or restorations on the root surface.

Teeth were cut along the transverse plane at the cementum-enamel junction with cementum being removed from the root fragment with a high-speed dental drill fitted with a 245 carbide burr. Thus, teeth samples now consisted of only root dentine (primary [1^{o}] and secondary/circumpulpal [2°]).

Dentine samples were dried to constant weight at 70°C and the entire sample analyzed for lead. For each 0.10g of dentine sampled, 0.5mL of trace-metal grade nitric acid was added and the sample digested overnight at room temperature followed by digestion of the acid-dentine mixture at 100°C for 6 hrs. A blank sample (trace-metal grade nitric acid) and bonemeal reference standard (US National Institute of Standards and Technology Standard Reference Material 1486) were included with each digest. Following digestion, samples were diluted with distilled deionized water (DDW) to a final acid concentration of 25%v/v and filtered through Whatman 42 ashless filter paper. Lead concentration was determined with a Perkin Elmer Model 460 graphite furnace atomic absorption spectrometer (detection limit 0.10 µg/g) calibrated using USNIST 1643c multi-element reference standard. Repeated readings of calibration were taken until absorbance values for a sample were within ± 10% of each other. A total of 13 bonemeal reference samples were digested and recovery of lead was on average within 10% of the expected value.

Tooth type was not considered because Bercovitz and Laufer (1990) have shown in adults that when two different tooth types were donated from the same individual there was no significant difference in root dentine lead levels. Further, Grandjean et al. (1979) found no tooth-type relationship in 2° dentine when one whole set of teeth was examined from an adult. Thus, average dentine lead levels and patient's age at date of extraction are reported for each individual who donated more than one tooth.

Dentine lead levels were transformed to natural logarithms to normalize the data. Dentine lead data for males and females were combined since they were not significantly different (ANOVA: $F=3.57$, $P=0.06$). Data were then divided into six age groupings with increments of 10 years (Bercovitz et al. 1993), except for the first (16-20 years) and last groups (61-84 years). Age groupings were used because lead levels in teeth increase with age of the individual (e.g. Frank et al. 1990; Bercovitz et al. 1993). Variation in dentine lead levels between age groups was assessed by analysis of variance (ANOVA) that employed an a-posteriori test, Student-Newman-Keuls (SNK), at the $\alpha=0.05$ level. The relationship between dentine lead level and age among individuals was assessed by linear regression analysis.

RESULTS AND DISCUSSION

No significant differences between males and females in dentine lead levels were found in the present study. Dentine lead levels in the whole sample of adult teeth ranged between 0.5 and 113.4 µg/g dry weight. Significant differences between several age categories for dentine lead levels in adults were evident (ANOVA: $F=8.69$, $P=0.0001$; SNK, Table 1). Dentine lead levels were also found to increase significantly with age ($r^2=0.35$, $P=0.0001$). The results of Bercovitz et al. (1993) were similar to the present study in that females and males did not differ significantly with respect to dentine lead levels and non-significant differences in dentine lead levels were reported for several consecutive age categories. A positive relationship between dentine lead levels and age was also found. Thus, we support the assertion by Bercovitz et al. (1993) that when comparing results to other studies, age categories must be considered.

In the present study, root dentine lead levels were generally found to be comparable to results of other studies even though our samples were obtained from a remote area and the others were much more urban and/or industrial (Table 2). However, it must be stressed again that for meaningful comparisons of results between adult dentine lead studies, similar age groupings must be examined. Further, differences in dentine lead levels for the different types of dentine must be recognized because it is known that 2° dentine lead levels can be at least threefold greater than root dentine lead values (Shapiro et al. 1972; Purchase and Ferguson 1986). These considerations must noted when comparing results in Table 2.

Table 1. Dentine lead levels of adults from Fort Albany, Ontario, Canada as a function of patient's age at time of tooth extraction.

Age Category (yrs)	Dentine lead level $\bar{x}\pm$SD (μg/g)	n
16-20[cd]	14.1±16.1	5
21-30[d]	8.1±9.8	33
31-40[bcd]	13.2±15.2	24
41-50[abc]	28.9±37.1	8
51-60[ab]	33.0±27.8	10
61-84[a]	44.7±23.0	9

Categories with the same superscript letters are not significantly different at the (α =0.05 level (ANOVA: Student-Newman-Keuls).

The two studies most appropriate for comparisons with the present study were by Frank et al. (1990) and Bercovitz et al. (1993). Dentine lead levels found in Strasbourg, Germany and Fort Albany, Canada were comparable, while dentine lead levels found in Mexico City, Mexico were greater than those in Fort Albany, Canada (Table 2). The most meaningful comparison is that of the present study to the Bercovitz et al. (1993) study since methodology is similar. By comparison lead levels in root dentine are greater in all age categories for Fort Albany, Canada compared to areas of northern and central Israel (Haifa Bay, Tel-Aviv, and Kibutzim). When the studies in Table 2 are viewed as a whole taking location (remote versus urban) and degree of industrialization into account, it is evident that there is an elevation of lead in root dentine collected from adults of Fort Albany, Canada. This elevation of lead in root dentine is surprising considering that Fort Albany is an isolated fly-in community with no industrial base and low levels of lead being reported in water, soil and air (OMHE 1989). Thus, the question arises: What is the source of lead exposure in this community?

Tsuji and Nieboer (1997) have shown that approximately 15% of randomly examined radiographic charts (views: abdominal; kidney, ureter, bladder) from Weeneebayko General Hospital (regional hospital for the western James Bay region) had evidence of pellets contained in the gastrointestinal tract, intraluminally and/or in the appendix. Lead shot that have been ingested and reside in the human gastrointesinal system have been shown to increase the body burden of lead (Greensher 1974; Madsen et al. 1988). In addition, several studies have found elevated lead levels ($\geq$ 0.5 µg/g wet weight, the level set for human consumption; Health Canada and Ontario Ministry of Health 1995) in portions of edible skeletal tissue from gamebirds harvested with lead shot (e.g. Hubbard et al. 1965). Elevated lead levels in wildgame

Table 2. Dentine lead levels (μg/g) of adults from several studies.

Location	Subjects' Age (yrs)	Dentine Type	Lead level $\bar{x} \pm sd$ (n)	Study
Strasbourg, Germany	10-29	1° dentine	12.4±7.1 (7)	1
		2° dentine[a]	17.3±7.2 (7)	
	32-65	1° dentine	24.6±10.2 (7)	
		2° dentine	45.3±15.8 (7)	
Mexico City, Mexico	12-29	1° dentine	24.1±9.3 (7)	1
		2° dentine	118.8±95.6 (7)	
Northern and Central Israel	14-20	root dentine[b]	1.6±0.8 (47)	2
	21-30		2.9±2.0 (79)	
	31-40		6.4±3.8 (24)	
	41-50		8.0±3.4 (19)	
	51-60		20.8±9.3 (8)	
	68-75		25.7±14.8 (3)	
Fort Albany, Canada	16-20	root dentine	14.1±16.1 (5)	3
	21-30		8.1±9.8 (33)	
	31-40		13.2±15.2 (24)	
	41-50		28.9±37.1 (8)	
	51-60		33.0±27.8 (10)	
	61-84		44.7±23.0 (9)	
Christchurch, New Zealand	unknown	root dentine	28.7 (5)	4
		2° dentine	96.6 (5)	
Philadelphia, USA	unknown	root dentine	42 (7)	5
		2° dentine	192 (6)	

[a] 2° dentine lead levels can be 3x root dentine levels.

[b] Root dentine consists of 1° and 2° dentine.

1 Frank et al. 1990.

2 Bercovitz et al. 1993.

3 Present study.

4 Purchase and Fergusson 1986.

5 Shapiro et al. 1972.

harvested with lead shot has been shown to be the result of embedding of whole lead pellets and/or lead fragments generated from the disruption of whole pellets upon impacting with bone (Frank 1986). Further, three studies in the western James Bay region have reported elevated blood lead levels in children and have suggested that lead contaminated wildmeats as the probable source (OMHE 1989; Hanning et al. 1997). Moreover, in the Hanning et al. (1997) study, cord and maternal blood lead was found to correlate significantly with the cosumption of a traditional diet of wildgame (fowl, mammal, and to a lesser extent fish). When these studies are considered as a whole, it is clear that harvesting wildgame with lead pellets increases the probability of increasing body lead burden. Banning of lead shot for all harvesting of wildgame should be considered due to human health concerns.

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