Journal of
Synchrotron Radiation

ISSN 0909-0495

Received 4 August 2008
Accepted 17 February 2009

Comments on *Migration of mercury from dental amalgam through human teeth* by H. H. Harris *et al.* (2008). *J. Synchrotron Rad.* 15, 123–128

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The recent paper by Harris *et al.* (2008) showed the relation between mercury migration from amalgam into a tooth restored with dental amalgam by using the X-ray absorption near-edge spectroscopy (XANES) method.

As noted by the authors, there is an important and continued debate regarding the potential adverse health outcomes related to mercury dental amalgam in the general population (Clarkson, 2002). This controversy focuses on the presence of mercury, which is a well known neurotoxicant, and the potential systemic adverse effects associated with the use of dental amalgam.

Metallic mercury from amalgam tooth fillings has been associated with various oral clinical–pathological inflammatory conditions in adults such as oral lichenoid reactions, oral lichen planus, cheilitis, oral leukoplakia, facial granulomatosis, burning mouth syndrome, systemic contact dermatitis and nummular lichenoid dermatitis (Mutter *et al.*, 2007). Specifically, oral lichenoid lesions, characterized by an autoimmune inflammatory process, are triggered by the different forms of mercury in an oral cavity. Therefore, treatment requires an accurate dental amalgam removal, which is the first and most effective therapeutic option (Dunsche *et al.*, 2003; Guzzi *et al.*, 2003).

In view of these data, several European Health Ministers have introduced protection laws which demand that dentists do not use mercury-based restorative materials in children aged six or under. Since January 2008, first Norway and subsequently Sweden and Denmark have banned the use of mercury dental amalgam.

Within this context, the authors discuss the possibility of a missing link between mercury released into the tooth structure and the total amount of mercury in the body. The authors hypothesize that the prolonged and/or permanent exposure *via* migration of mercury through the tooth may contribute significantly to the individual's mercury overload. They further theorize the possibility that mercury migration through the tooth may be a new pathway of mercury able to seriously confound epidemiological results.

Little is known about the effects of mercury on the structure of dentin and enamel. An experimental animal model has shown that mercurial compounds have been associated with abnormalities in teeth during the embryonic development. In particular, mercury may interfere with the process of dentin formation and reduce the length of the teeth (Yonaga *et al.*, 1985).

With regard to the study by Harris and colleagues, we would like to express our concern about the removal procedure of dental amalgam used in the amalgam-restored tooth as a model to assess exposure to metals from mercury dental amalgam. The authors state that 'Amalgam fillings and linings were removed after extraction with a high-speed dental drill'. It is well known that dental amalgam removal causes high levels of mercury vapor in intraoral air (Richards & Warren, 1985) and in tooth space compartments (*e.g.* enamel, dentin, roots) surrounding the drilled dental amalgam (Guzzi *et al.*, 2003).

Thus, there is evidence that areas of dental tissues can be heavily more contaminated with mercury than in the initial condition prior to dental amalgam removal procedure. Physically, mercury atoms, which have diameters of 0.3 nm, are able to diffuse freely through dentinal tubules measuring between 0.9 and 2.5 μm in diameter.

Other metals, for their part, may be deposited into dentin matrix layers during cutting of dental amalgam by high-speed dental instrumentation.

In our preliminary data (unpublished), we were able to measure directly the levels of mercury vapor release from the surface of tooth cavity after amalgam removal. Mercury vapor levels were approximately 250 to 500 ng m^{-3}, indicating that mercury can easily accumulate up into dentin and then be released.

Likewise, there may be a marked and direct metals deposition within the dentin released from metal components, which constitute the alloy powder of amalgam. Using the technique of atomic absorption spectrometry, we found that dentin with amalgam discoloration may contain other metals: Cu 600 μg g^{-1}; Ag 215 μg g^{-1}; and Pd 3.9 μg g^{-1} (our unpublished data) (see Fig. 1).

As far as we know, the only dental approach that may circumvent the risk of widespread contamination of dental tissues with elemental metallic mercury is termed the 'lift-on technique' (Guzzi *et al.*, 2003, 2004).

Briefly, our protocol consists of dislodging and removing the mercury dental amalgam, in its entirety, from the clinical crown of the tooth by cutting out circumferentially 1 mm and/or 1.5 mm of the dental tissue (enamel and dentin) (Guzzi *et al.*, 2003). In other words, we do not perform the drill-out of dental amalgam. We believe that this procedure for selectively removing mercury dental amalgam is preferable in order to estimate, more precisely, the migration of metals into the dental hard tissue of tooth.

On the clinical side, as clinicians who treat patients with amalgam-related clinical adverse effects, we would have preferred to see a clear picture of the tooth cavity soon after the dental amalgam removal.

In this way, we could have correlated the potential deep dentin heavy metal discoloration, owing to amalgam corrosion, with the measurements that the authors have found by using the XANES method.

We have different views from Harris and co-workers about the interpretation of Hg penetration into the bloodstream. The contribution of the mercury through mercury amalgam-restored teeth, which release mercury directly into the bloodstream of a pulp vascular system, to cumulative body burden appears to be negligible compared with the mercury vapor inhaled from the oral cavity as well

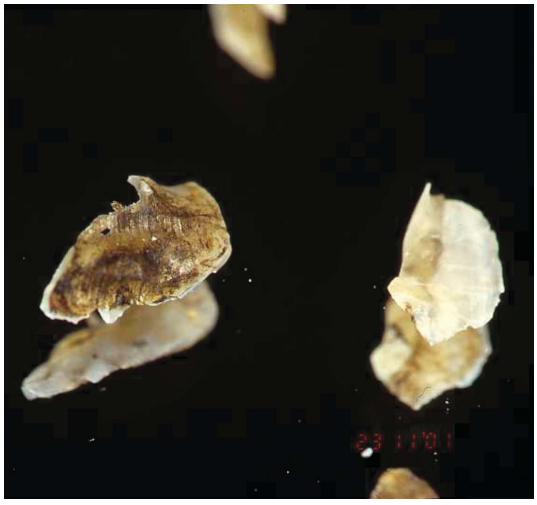

Figure 1
Amalgam-pigmented dentin fragments from the surface of a tooth cavity after amalgam removal. Metals deposition within the dentin released from metals components, which constitute the alloy powder of amalgam, are visible. Significant amounts of copper, silver and palladium have been found by using atomic absorption spectrometry.

as the mercury vapor dissolved in saliva and subsequently swallowed, particularly after prolonged mastication among individuals who have amalgam-restored surfaces (Clarkson, 2002; Haller *et al.*, 1993; Horsted-Bindslev *et al.*, 1997; Eide *et al.*, 1994). For example, subjects that either use chewing gum or are affected by bruxism may have a higher intake of mercury from dental amalgams (100 µg per day; Lorscheider *et al.*, 1995) and high mercury vapor levels that exceed the occupational health limits (Clarkson, 2002).

Likewise, because of the low content of both organic and inorganic mercury in calculus, its contribution as a source of mercury amalgam is negligible (Pigatto *et al.*, 2005).

Finally, although difficult to gauge, the influence of potential intra-oral galvanic current (Toumelin-Chemla & Lasfargues, 2003) on the accumulation of metals underneath amalgam restorations could account for the variability in metals disposition into dental tissues of an amalgam-restored tooth.

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