Mercury and dentistry

The controversy continues.

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Until such a time as low levels of mercury are definitively linked to ill-health, we must assume that the use of mercury amalgam is safe. However we should be diligent in protecting our patients and ourselves from mercury in our working environment, especially in light of the percentage of offices where mercury levels exceed the recommended levels.

The introduction of dental amalgam restorative techniques to North America by the Crawcour brothers in 1833 revolutionized dentistry[1]. Prior to this, conservative restorative dentistry consisted entirely of gold-foil restorations. Because of the expense of gold-foil, access to restorative dental treatment was limited to the wealthy. Amalgam restorations simplified restorative dentistry and reduced its cost making dental treatment available to a large sector of society. Despite this, the use of amalgam restorative techniques was surrounded by controversy.

Initially, the Crawcour brothers (1833) recommended amalgam placement without cavity preparation thereby promoting amalgam restorations as dental treatment that was both inexpensive and painless[1,2]. Many treatment failures occurred as a result of this unsound philosophy. These failures as well as amalgam's potential neurotoxicity resulted in much discord in the dental profession at the time. At the height of the "amalgam war" of 1843, the American Society of Dental Surgeons (A.S.D.S) condemned the use of amalgam by its members[1]. This did little to deter its use since the A.S.D.S. represented less than one-third of practising dentists.

At the turn of the century, Dr. G.V. Black applied sound scientific principles to the study of mechanical properties of amalgam and its application to restorative dentistry[3]. This led to the eventual standardization of the manufacture of dental amalgam and design of amalgam cavity preparations[4]. Except for the introduction of high copper amalgam alloys in the 1960's[5] the basic constituents and placement of amalgams has seen little change.

Mercury in amalgam was a minor issue during the amalgam wars due to the lack of understanding of mercury toxicity by the general public and the absence of regulatory agencies.

The potential toxic effects of mercury in amalgam were first reported in the mid-twenties by Stock (1926)[6] who postulated that mercury absorbed from dental amalgams could lead to serious health problems. After further consideration Stock recanted his earlier claims[2]. Throughout this century and especially in the 1980's, isolated cases of neurotoxicity and apparent systemic disorders have been supposedly linked to dental amalgam.

In a recent article in the lay press (Toronto Star: January 13, 1988), a 31-year-old man attributed a 15-year history of fever, breathing difficulty, leg cramps, lethargy, and reduced academic performance to the presence of amalgam restorations placed 20 years previously. The patient claimed that it was not until his amalgam restorations were replaced with composite resins that the quality of his life improved.

These unscientific reports create public hysteria about simple dental restorative treatment. Although as recently as 15 years ago public concern over the health hazards of dental amalgam was unheard of, today it is not unusual for a dentist to have to answer patients questions concerning the safety of dental amalgams. This being the case, it is important that the dentist have an appreciation of how recent research in this subject has demonstrated that aside from those few who exhibit a true allergy to mercury, amalgam poses no health hazard to the general population. Mercury allergy is rare and is mediated via a type IV hypersensitivity reaction[7]. It may manifest clinically as dermatitis or stomatitis[2] and lichen planus and lichenoid lesions of the mouth may be

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Fast track

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associated with true mercury sensitivity[2]. In addition, it is important that the practitioner be familiar with the potential occupational hazards of using mercury-amalgam. This dissertation will address these two problems.

Chemistry and biology of mercury

Mercury is a peculiar element in that it is the only metal that is liquid at room temperature. Its vapour pressure is temperature sensitive and it is therefore a potential health hazard in enclosed areas. Mercury is found in three major forms: elemental or metallic mercury (which includes mercury vapour), inorganic mercury (including mercury salts such as mercury chloride) and organic mercury (such as methyl mercury).

Methyl mercury is the most toxic form of mercury and is usually found in poisoned foods such as fish from polluted waters or insecticide-sprayed grain products[2,7,8,9,10]. It is liquid soluble and is easily absorbed through the gastro-intestinal tract into the bloodstream where it readily crosses the blood-brain barrier[8,9]. Once in the brain, methyl mercury is oxidized to ionic mercury which remains in the tissues of the central nervous system. A toxic dose of methyl mercury will classically manifest itself clinically as a neurologic disorder. In addition, methyl mercury tends to accumulate in the gastro-intestinal tract mucosa and in the acinar cells of the salivary glands. As a result, disturbances of the gastro-intestinal tract, gingivitis, loss of alveolar bone and a peculiar metallic taste may be associated with mercury toxicity. A complete list of the potential side effects of mercury are listed in Table 1.

Fortunately, mercury from amalgam makes itself available to the body as either elemental mercury or as a mercury salt[2,10]. Recent reports that certain oral bacteria can methylate mercury *in vitro* have not been supported by *in vivo* investigations[2,10].

Eighty percent of inhaled mercury vapour is believed to be absorbed by the lungs[2,9,10]. Another avenue for the absorption of elemental mercury as well as inorganic mercury is via the gastro-intestinal tract[2,10]. Fortunately, only 10 percent of mercury in these forms is absorbed by the lining of the G.I. tract.

Once in the blood, elemental mercury is quickly oxidized by the red blood cells into the ionic form (Hg 2+). Since ionic mercury does not pass the blood-tissue barrier well it collects in the kidneys. An insignificant quantity of mercury is not oxidized making it available to the brain. Toxic levels of elemental mercury and inorganic mercury are associated with neurotoxicity and disturbances of the gastro-intestinal tract, gingiva and saliva[11].

Risk of mercury toxicity from amalgam restorations

Combustion products of fossil fuel, ingested foods, applied soaps and cosmetics and dental amalgam are a few of the more common sources of mercury in the body. The dental community has always been concerned with the hazards of mercury from dental restorations[2,10].

The patient

Elemental and inorganic mercury are the only potential toxic forms of mercury from dental amalgam restorations. Accidental introduction of amalgam material into the tissue of the mouth (the so-called amalgam tattoo) are thought to be trivial in regards to toxic mercurial effects[2,10]. Ingestion of free mercury in the form of corrosion products or newly-set amalgam particles during insertion have minimal toxic effects since such a small percentage of mercury is absorbed through the lining of the digestive tract[2,10]. The threshold-limit-value (TLV), set at 50 ug/M 3 is the mercury concentration in the air of a working environment which is considered safe[2,10] and is based on an average working week of 40 hours. Others consider half the TLV to be acceptable for the normal non-mercury working person[10]. In addition, short-term exposure below 500 ug/M 3 is considered safe[10]. These values are derived from data on the toxicokinetics and toxicodynamics of ingested mercury.

Table 1: Signs and symptoms of acute high doses or chronic low exposure to mercury.

Central Nervous System	convulsions anorexia irritability depression fatigue personality disorders insomnia
Neuromuscular	loss of fine motor control tremors
Gastro-intestinal	nausea diarrhea gastritis
Genito-urinary	nephritis
Oral manifestations	gingival mercury deposits loosening of teeth ulceration of oral mucosa enlarged tongue excess salivation metallic taste

Enwonwu (1987) argues that this derivation is based on "*many scientific uncertainties and assumptions*"[9]. Nevertheless these values serve as guidelines so as to make comparative analysis with data that is actually available and not as undisputed absolutes.

Intact amalgam restorations have been a concern to the dentist since the time it was found that higher levels of mercury vapour were found in the expired air of persons with amalgam restorations[2,10]. The level of mercury in the expired air is dependent on the number of surfaces restored with amalgams[2,10]. In addition, an increase of as much as tenfold has been measured soon after brushing the teeth or chewing gum although levels returned to pre-brushing levels quickly[2,10]. It is important to realize that reported values vary by a factor of 10 probably because of the different methods of measuring mercury in expired air[2,9,10]. Expired air mercury levels ranged from 4.91 ug/M 3 (prior to chewing) to 29.10 ug/M 3 during chewing gum in a report by Vimy and Lorscheider (1985)[11]. Otto and co-workers (1984) reported values that were significantly lower (0.29 ug/M 3 and 1.35 ug/M 3 prior to and during chewing respectively[12]). Mackert (1987) demonstrated that Vimy and Lorsheider's values should be reduced by a factor of 16 because the rate of breathing and tidal volume used in their experimental technique differed substantially from normal respiration[13]. Although higher levels of mercury are found in the expired air of those with many amalgam restorations, the values remain well below the recommended TLV[13].

Mercury levels in blood and urine are relatively good indicators of mercury absorption[2,8,9,10]. The relationship between the number of amalgam restorations and the level of mercury in the blood or urine has not been thoroughly investigated as in that of expired air. However, all reported values thus far[2,8,10] are well below the upper limit of normal which is 20 ug/100 ml blood and 15 ug/l for urine[2].

The relationship of amalgam restorations to the accumulation of mercury in brain tissue was addressed by Eggleston and Nylander (1987)[14]. They measured the amount of mercury in brain tissue taken from cadavers with or without amalgam dental restorations and found a positive correlation between the number of occlusal surfaces of dental amalgam and mercury levels in the brain. Eggleston and Nylander did not however, have data to support any deleterious side effects associated with the presence of these increased mercury levels while the subjects were alive.

Risks to dental health personnel

Although as health-care workers we should always be concerned with minimizing the mercury-related health-risks to our patients, we must also consider the dangers to dental personnel since it is these persons who are chronically exposed to mercury in their working environment. The sources of mercury in the working environment are summarized in Table 2.

From 10 to 17 percent of dental offices in North America reported mercury levels in the working environment above the TLV[2,15]. This has been a concern to the dental profession and steps have been taken by professional societies to eliminate this threat (Table 3).

Pre-packaged disposable amalgam capsules have done much to reduce mercury spillage in the dental office but they are still major sources of mercury vapour during trituration[2,8,15]. Removal of old amalgam restorations using proper water-spray and high-volume suction has been shown to eliminate the risks of ingesting amalgam and inhaling mercury vapour[2,8].

Table 2: Potential sources of mercury contamination in the dental office.

- Accidental mercury spills.
- Mechanical amalgamators.
- Amalgam condensation.
- Ultrasonic amalgam condensors.
- Removal of old amalgam restorations.
- Poor disposal of unused mercury amalgam.
- Hot-air sterilization of amalgam-contaminated instruments.

Table 3: Recommended mercury hygiene procedures.[18]

- Prompt clean-up of all mercury spills.
- Well ventilated operatories.
- Monitoring for air-borne mercury once per year.
- Use of disposable pre-capsulated amalgams.
- Amalgam triturator arms should be enclosed during trituration.
- No contact of mercury with skin.
- All amalgam scraps should be salvaged and stored in a tightly closed container partially filled with a sulfide solution such as dental x-ray fixer solution.

Both the dentist and the dental assistant are at risk from exposure to mercury vapour during the restoration of teeth with amalgam materials although perhaps the dental assistant is at greater risk due to handling of amalgam and her proximity to the triturator. Despite the definite increase in ingested mercury in dental personnel there is no evidence to suggest that dental assistants, or the wives of dentists suffer from increased spontaneous abortions or abnormalities in their offspring[2].

White and Brandt (1976) report a positive correlation between hypersensitivity to mercury in dental students and their academic year in dentistry[16]. Recently, however, Miller and co-workers (1987) contended this concept suggesting that White and Brandt's findings were related to the increased use of disposable alloy

capsules as well as improved mercury hygiene practised in modern dental schools[17].

It appears that any risk of mercury in amalgam to the dental health team and the general public is acceptably low. It seems that mercury toxicity related to dental amalgam comes exclusively from elemental and inorganic forms. Furthermore, research demonstrates that levels of mercury in the expired air of patients, and the blood and urine of dental health personnel were within recognized acceptable limits. The concentration of mercury in the ambient air of most dental offices was also within accepted values. Furthermore, for approximately 150 years, amalgam has been used as a dental restorative material with no proven deleterious effects.

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