The Efficacy of the IAOMT Engineering Controls Used During Removal of Mercury Silver Dental Restorations

Explanation of IAOMT position: "This review is the first to quantify the mercury released during dental mercury amalgam removal. The data mandates that more serious consideration be given by all dentists, worldwide, to protecting themselves, their staff and patients from exposure and consequences of mercury vapor and particulate during mercury amalgam removal procedures. While the data is in its infancy the impact and ramifications of this data warrants immediate consideration by the academy. This review in its current form is not intended to shape the academy’s position or require immediate action but is intended to stimulate discussion and raise awareness of our current systems during Hg removal.

As such this review has not been given approval by the Scientific Review committee. We have every expectation that it will be in the future. For now, we prefer that the data speak for itself and a healthy discussion to begin that will guide and shape the conclusions of this study.

The explanation and ramifications of mercury exposure can be found in the "International Academy of Oral Medicine and Toxicology (IAOMT) Position Statement against Dental Mercury Amalgam Fillings for Medical and Dental Practitioners and Patients" found at www.IAOMT.org. Expect constant updates and enhancements to this SR in the future."
**Scientific Review History:**
5. Ziff, update Sukel (2005) Reducing Mercury Vapor Exposures for Doctor and Staff During Amalgam Removal

**A brief description of the Scientific Review:** We designed a study to measure Hg vapor and particulate levels using IAOMT recommended controls while removing mercury silver fillings and using procedures recommended by the American Dental Association.

Our data indicates that with all engineering controls in place (Tact-Air, Clean-up, IQ Air Cleaning Device, Water Spray, and Suction) the dentist, patient, and assistant are exposed to mercury at levels that exceed the level allowed by the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), and the Agency for Toxic Substances and Disease Registry (ATSDR). The average levels are generally lower when engineering controls are in place. However even with all engineering controls in place practitioners, assistants and patients are exposed to high levels of mercury particulate.

Engineering controls are required to keep levels as low as possible, but do not provide enough protection to eliminate exposure by inhalation to mercury vapor and particulate nor prevent direct contact with mercury particulate to exposed skin surfaces or clothing worn by the dentists, team members, and the patient. Our test showed that vapor and particulate can not be separated. Vapor generated during the removal of mercury fillings contains particulate and the presence of particulate on any surface will emit vapor.

Scrubs, uniforms, and cloth masks do not provide any form of protection to the dentists or team members and may increase exposure as mercury particulates accumulate with multiple procedures. Our data show that while our current engineering controls reduce exposure by as much as 2000 times there is still a significant exposure. We suggest that additional measures should be employed to further reduce mercury exposure, including full-face respirator mask designed to filter mercury vapor and mercury particulate.
A specific description of this Scientific Review:
Six sessions removing 8 two surface mercury silver fillings from a simulated patient. Hg particulate, Hg vapor and particulate, and Hg vapor were measured for each session. The first session all controls were in place, a control was removed for each session until no controls were used. The same methods were used to collect data for each session.

Session One - Clean-up, Water, IQ Air, Tact Air,  
Session Two – Clean-up, Water, IQ Air,  
Session Three – Regular Intra-oral Suction, Water, IQ Air  
Session Four -  Regular Intra-oral Suction, Water  
Session Five –  Regular Intra-oral Suction  
Session Six -  No controls (cutting dry)  

During each session three different sets of mercury concentrations were recorded and are labeled as follows:

**Peak Mercury Vapor Levels (ug/m³).** – Measured at the Dentists, and Assistants shoulder using a Mass Spectrophotometer 3000  
**Average Mercury Vapor Levels (ug/m³).** – Measured at the Dentists, and Assistants shoulder using a Mass Spectrophotometer 3000  
**Mercury Particulate and Vapor (ug/m³).** – Measured at the Dentist and Assistants shoulder using Air sampling pumps and tubes with cellulose ester filters  
**Mercury Particulate (ug/100 cm²) – Measured by swab of a 100 cm² section from the same sites on the assistant and patient for each session.**

DATA:
We expected to see all values increase as engineering controls were removed. Our goal was to determine the effectiveness of each control so that the safest protocol could be recommended for dental teams as they remove mercury silver fillings.

OSHA has not established occupational levels for mercury particulate except for a general warning that it should not be allowed to accumulate on surfaces. There is no safe level for the chronic exposure that is received by the dental team. A level for mercury vapor of 0.2 ug/m³ was determined to be the lowest concentrations known to cause any level of harm to humans (the lowest toxic concentration level for humans [TCL0]) by a joint workgroup of the Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease Registry (ATSDR):

**Chemical-Specific Health Consultation**  
**for Joint EPA/ATSDR National Mercury Cleanup Policy Workgroup**  
**Action Levels For Elemental Mercury Spills**  
**March 22, 2012**

“Both ATSDR and EPA have developed health guidance values (HGVs) for inhaled mercury vapors, based on a 1983 study of workplace exposures [Fawer 1983]. The workers in the study were exposed in their workplace to mercury vapors. The workers in the Fawer cohort came from three different types of workplaces: fluorescent tube manufacture; chloralkali plants; and acetaldehyde production. The authors reported a Lowest Observed Adverse Effect Level (LOAEL) of 26 ug/m³ of exposure averaged over a period of 15 years [Fawer 1983]. As discussed below, the effect noted in the study was a slight tremor in the hands. ATSDR has defined a Minimal Risk Level (MRL) for chronic exposures (more than 365 days) to mercury of 0.2 ug/m³. In developing the MRL, the workplace average from Fawer was adjusted from a 40-hour to a 168-hour exposure per week (i.e., 24 hours/day, 7 days/week), and then divided by an uncertainty factor of 30 (3 for use of a minimal LOAEL and 10 for human
variability) to account for the LOAEL and individual sensitivities."

The mercury vapor peak levels in the next four graphs obtained from the Mercury 3000 cold mass spectrophotometer show a linear increase in mercury vapor as engineering controls were removed. With all controls in place the values were lower but above the 0.2 ug/m3 MRL for Hg vapor.

**Peak Mercury Vapor Levels**

![Graph](image1)

**Average Mercury Vapor Levels**

The average levels were obtained in the same fashion as the peak mercury levels but were averaged over the course of the session rather than the peak value obtained during the session. A linear increase in exposure occurred as each engineering control was removed. The values with all controls were greater than the 0.2 ug MRL.
Mercury Particulate and Vapor

Mercury vapor combined with mercury particulate was collected using air sampling pumps and tubes (Carulite Lot 7403 SKC, Cat. No. 226-17-1A) and cassettes with un-weighed, mixed, cellulose ester filters. The samples were analyzed by Galson Laboratories Inc. using NIOSH method 6009.

The sampling pumps, which collected particulate and vapor, always detected larger amounts of mercury than just measuring the vapor alone with the Mercury 3000. This was the first indication in the study data that particulate could be contributing to a significant overlooked exposure source.
**Mercury Particulate**

Surface sampling for particulate was conducted with 2 inch by 2 inch sterile gauze that was moistened with deionized water prior to wiping a surface of interest. Wearing new disposable gloves for each wipe sample, the industrial hygienist moistened the gauze and wiped a 100 cm² area with the gauze. Several sites were sampled for the assistant and the patient. The samples with the greatest particulate values are shown. The samples were analyzed by *Galson Laboratories, Inc.*

The surface sampling for particulate showed a consistent increase in mercury sampling on the patient and assistant as engineering controls were removed. The assistant’s knee closest to the operative site maintained the highest levels of particulate. A value of 330ug was found on the patient’s chest with all controls in place, which is 10 inches (25 cm) from the operative site. The peak values steadily increased as engineering controls were removed. The patient’s highest levels of particulate were found on the chest with particulate traveling to the knee after the tact-air and clean-up were removed. Particulate measurements steadily increased in value and particulate was detected further from the operative field as engineering controls were removed.

**Total Mercury Vapor**

The total mercury vapor per session detected by the Mercury Instruments 3000 cold mass spectrophotometer ([www.mercuryinstruments.com](http://www.mercuryinstruments.com)) is shown in the following graphs and in Table six. The Mercury 3000 cold mass spectrophotometer monitored the vapor in real time during the removal, including the five minutes we waited each session before collecting surface samples for particulate. The total mercury vapor for each session was available from the data collected by the Mercury 3000. The total mercury vapor for each session increased in a linear progression as each control was removed. Time was not a factor as shorter operative segments still showed an increase in quantity of mercury vapor. It is important to evaluate the total mercury vapor as the dentist and assistant are exposed to the entire mercury vapor that is created by a procedure and not just to the averages and peaks.
Discussion

No limits for mercury particulate amounts have been set, but OSHA compliance directive cpl-02-02-006 states “all exposed surfaces should be maintained free of accumulation of mercury, which, if dispersed would result in airborne concentrations in excess of the permissible exposure limit or in a visible dust cloud”. NIOSH assigns a "Skin" notation, which indicates that the cutaneous route of exposure, including mucous membranes and eyes, contributes to overall exposure [NIOSH 1992] [9]. As the dentist and team members are exposed multiple times during a normal work day, this discussion will assume for any level of exposure above zero for mercury vapor or mercury particulate, maximum personnel protection procedures should be used for the patient, dentists, and team members.

In a 10 square foot room, 5 ug of vaporized mercury would elevate the air concentration of mercury to the Agency of Toxic Substances and Disease Registry Minimal Risk Level.  The data from sessions one (All Controls) and two (Tact-Air Removed) shows the dentist assistant and patient are exposed to mercury vapor and mercury particulate that far exceeds this level by 7-50 times. Within the radius of our surface sample exists the potential bare skin of the patients face, oral mucosa, chest, and neck as well as the dental workers hands, wrists, arms, and neck. Contamination with mercury particulate of clothing worn by the team during an eight hour work day constitutes a significant chronic exposure to mercury.

The following recommendations are currently taught by the IAOMT to members to reduce mercury exposure for the patient and the dental team:

1. Use nitrile dam material and gloves at all times when removing silver mercury fillings. The routine use of a rubber dam has repeatedly been shown to reduce exposure of the patient and the operator to mercury vapor when drilling amalgam in humans (Nimmo et al. 1990, Berglund et al. 1996).
2. Always use a high volume of water and suction, while removing silver mercury fillings, and remove in as large chunks as possible.
3. Provide the patient oxygen or air with a delivery system that covers the nose of the patient to prevent inhalation of vapor and particulate
4. Place a saliva ejector under the dam to reduce vapor exposure to the patient
5. Use engineering controls, Tact-air, clean-up, high volume auxiliary suction devices designed to filter mercury particulate and mercury vapor
6. The dentist and any team member present should wear a respirator type mask equipped with a mercury vapor and mercury particulate filter
7. HgX cream (Acton Industries) should be applied to all exposed skin surfaces
8. Use whole room filtration systems with activated charcoal filters to maintain air quality.

The data in this study indicates that additional measures also need to be taken to protect exposed skin and clothing for the dentist, assistant, and patient to prevent contact with mercury vapor and mercury particulate. This contact
may be a sub acute, low level of chronic mercury exposure, when all recommended engineering controls are in place with the potential for high peak exposures to mercury vapor and mercury particulate. The Alberta Occupational Health and Safety manual states “an employer must ensure that a worker’s skin is protected from a harmful substance that may injure the skin on contact or may adversely affect a worker’s health if it is absorbed through the skin. The data obtained in this study, especially the exposure to mercury particulate, indicates additions to the IAOMT recommended protocol should be considered: Appendix A explains the recommended additions.

CONCLUSION
Dentists that practice with no engineering controls in place are at risk of exposure to mercury vapor and particulate by inhalation, accumulation on clothing, and absorption through exposed skin. Dentists and assistants following the current recommended IAOMT engineering protocols are protected from inhaling mercury vapor and mercury particulate, but are still exposed to accumulation of particulate on clothing and absorption of mercury vapor through their skin. Dentists and assistants should consider the use of full coverage barrier protection with disposable coveralls and the utilization of mercury vapor masks with full face protection to protect against contamination from particulate. Further research will be required before the ideal material for barrier protection can be determined.


Journal Prosthetic Dentistry, 1990 Feb 63(2):228-33 Particulate Inhalation During the Removal of Amalgam Restorations Nimmo A, Werley MS, Martin JS, Tansy MT, Department of Prosthodontics, Temple University School of Dentistry, Philadelphia, Pa

Human and Ecological Risk Assessment, Inhalation of Hg Contaminated Particulate Matter by Dentists: An Overlooked Occupational Risk, Oct 1, 2003 Richardson, G. Mark

Legal Aspects of this Scientific Review: A member in the IAOMT should do all that is necessary to protect the patient and team members from exposure to all forms of mercury. OSHA and Health Canada require that employees be informed of any possible workplace hazards and when hazards are present they have to be trained and provided with necessary protective equipment. Providing training, respirators for mercury vapor and particulate, and protective garments for exposure to mercury particulate would be a beginning to meet OSHA and Health Canada standards.

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