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Human brain mercury levels related to exposure to amalgam fillings

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Abstract

The safety of dental amalgam as the primary material in dental restoration treatments has been debated since its introduction. It is widely accepted that amalgam restorations continuously release elemental mercury (Hg) vapor, which is inhaled and absorbed by the body and distributed to tissues, including the brain. The aim of the present study was to investigate whether the presence of amalgam fillings is correlated with brain Hg level. The Hg levels in the parietal lobes of the brains of 32 cadavers were analyzed with an atomic absorption spectrometer with the mercury hydride system. A total of 32 brain samples were tested; of these, 10 were from cadavers with amalgam fillings, while 22 of them were amalgam free. Hg was detected in 60.0% (6 of 10) of the samples in the amalgam group and in 36.3% (8 of 22) in the amalgam-free group. The average Hg level of the amalgam group was 0.97 $\pm$ 0.83 μg/g (minimum: 0.3 μg/g and maximum: 2.34 μg/g), and in the amalgam-free group, it was 1.06 $\pm$ 0.57 μg/g (minimum: 0.17 μg/g and maximum: 1.76 μg/g). The results of the present study showed no correlation between the presence of amalgam fillings and brain Hg level.

Keywords

Amalgam, brain mercury, toxicology

Introduction

Amalgam, an alloy of mercury (Hg), is an excellent and versatile dental restorative material containing about 50% Hg, and the rest principally silver and small amounts of copper, tin, and zinc.[1–3] Dental amalgam restoration has been used in dentistry for more than 150 years due to its low cost, ease of application, strength, durability, and bacteriostatic effects.[4,5] For various reasons, including the development of viable alternatives based on resins and ceramics, and perceptions of a dubious and frequently questioned level of safety, the popularity of amalgam restoration has declined.[2,6] In addition, the metallic color of amalgam does not blend with the natural tooth color so patients prefer tooth-colored restorative material for cavity filling in carious teeth for better aesthetics,[5] but countless amalgam fillings remain and are still serving in patients' mouths.

Although other filling materials are available, the popularity of amalgam is maintained by its relative cheapness, durability, ease of use, and antibacterial aspects.[3,7] In many countries, amalgam is still the most commonly used filling material in posterior teeth.[4,8] The main controversy is focused on the Hg content of amalgam. The use of Hg in dentistry has

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been controversial since the middle of the 19th century, as inorganic Hg can cause a wide variety of health problems, particularly in the neurological and renal systems. This controversy has intensified over approximately the last 20 years because highly sensitive analytical techniques have shown Hg to be continuously released from dental amalgam fillings and absorbed into the body. A variety of potentially toxic compounds may be released from restorative dental materials, amalgam, and composites and diffuse into the tooth pulp or gingiva, reaching the saliva and the circulating blood.[9–12]

Amalgam fillings are considered to be the primary source of inorganic and vapor Hg for the general population. It has been reported that the number of amalgam surfaces and brain Hg level at autopsy are related and that some Hg exposure is due to dental amalgam, even though the levels in the brain are thought to be so low that adverse events may occur mainly in genetically susceptible individuals.[13–15]

Hg passes the blood–brain barrier readily, and in sufficient quantity, it causes neurological dysfunction.[15–18] It now appears to be established that the daily absorbed dose of Hg from amalgam restorations of an average individual is quite low, at about 1–2 μg of inhaled Hg and <1.5 μg of ingested Hg. It seems unlikely that these low levels would constitute a health hazard. However, individuals with a large number of surfaces restored with amalgam and elevated release rates resulting from chronic gum chewing and erosive activities involving grinding would be exposed to significantly higher levels.[16]

Hg is a neurotoxin, with metallic Hg causing erythrism and methyl mercury (MeHg) causing Minamata disease. Toxicity can occur from inhaling Hg vapors, a potential source of which is dental amalgam. Researchers agree that Hg leaches from amalgam restorations into the mouth but consistent findings are not available to indicate whether it poses a significant health risk.[5,7,19,20]

Levels of some trace elements, including Hg, have been reported to be imbalanced in patients with Alzheimer's disease (AD), and it has been speculated that this imbalance may play a role in the disease. Hg levels have been reported to be elevated in some brain regions in patients with AD and in the microsomal subfraction of patients with AD and age-matched control subjects.[5,21]

In the present study, we investigated in autopsy cases whether exposure to Hg vapor from amalgams is associated with Hg deposition in the parietal lobe of the brain.

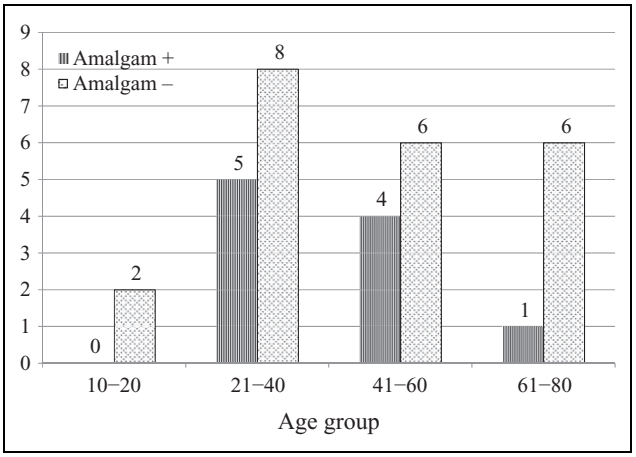

Figure 1. Distribution of age groups with amalgam and without amalgam. Brain tissue samples were collected from the parietal lobes of autopsy subjects aged between 17 and 71 years (mean 43 years).

Materials and methods

Prior to commencement of this study, permission was granted by the Human Ethics Committee of Ondokuz Mayis University (OMU), Samsun, Turkey. Between 2005 and 2009, postmortem samples were obtained from the parietal region of the brains of 32 cadavers aged from 17 to 71 years during the routine autopsy casework of the medical faculty of OMU (Figure 1). The brain samples taken from all cadavers were stored in a deep freezer at −80°C until the analysis. Each cadaver's sex, age, and number of teeth with amalgam fillings were recorded. To determine their Hg levels, the samples from the parietal lobes of the brains of the 32 cadavers were tested. Of these, 10 were from the amalgam fillings group, while 22 were from the amalgam-free (control) group.

The brain tissue samples taken for analysis precisely weighed 0.5 g. To this, 3 ml of 65% nitric acid and 0.5 ml of hydrogen peroxide were added to the sample which was then digested in a microwave acid digestion unit (Milestone MLS-1200 MEGA, MILESTONE, Italy). The digested sample was quantitatively transferred to a 10.0-ml volumetric polypropylene tube, and the final volume was adjusted to 10.0 ml. Standard solutions of Hg were prepared at various concentrations in the range of 5–20 ng/ml. Determinations of Hg concentration were performed with a PerkinElmer AAnalyst 800 atomic absorption spectrometer employing the Perkin Elmer MHS 15 mercury hydride system (Shelton, Connecticut, USA).

Results

Hg was detected in 60% (6 of 10) of the samples in the amalgam group and in 36.3% (8 of 22) of samples in the amalgam-free group. The average Hg level in the parietal lobe tissue of the amalgam group was 0.97 ± 0.83 μg/g (minimum: 0.3 μg/g and maximum: 2.34 μg/g), while in the amalgam-free group it was 1.06 ± 0.57 μg/g (minimum: 0.17 μg/g and maximum: 1.76 μg/g; Table 1).

Table 1. Hg levels in test specimens from the parietal lobe of cadavers.

Sample	Group	Age	Gender	Number of amalgams	Hg (μg/g)
1	Control	31	M	0	**1.29**
2	Control	63	M	0	–
3	Control	47	M	0	**1.76**
4	Amalgam	32	M	1	**0.77**
5	Amalgam	45	M	7	–
6	Control	38	M	0	**0.37**
7	Control	24	M	0	–
8	Control	20	M	0	–
9	Control	56	M	0	–
10	Control	71	M	0	–
11	Control	17	M	0	–
12	Control	63	M	0	–
13	Control	55	F	0	–
14	Control	46	M	0	–
15	Control	40	M	0	–
16	Control	35	M	0	**2.34**
17	Control	36	F	0	**1.72**
18	Control	46	M	0	**0.36**
19	Control	35	M	0	**1.00**
20	Control	53	M	0	–
21	Amalgam	48	M	3	**0.86**
22	Amalgam	66	M	0	–
23	Control	66	F	0	–
24	Amalgam	23	M	1	**0.17**
25	Amalgam	23	F	1	–
26	Amalgam	29	F	2	–
27	Amalgam	41	M	1	**0.46**
28	Amalgam	32	M	3	–
29	Amalgam	48	M	4	**1.34**
30	Control	66	F	0	**1.59**
31	Control	66	M	0	–
32	Control	23	M	0	–

Hg: mercury.

Conclusions

Dental amalgam is a metallomatrix composite; the bonds in intermetallic compounds are very stable and a great deal of energy is needed to break them. Further, after initial setting and hardening, it is considered inert. However, Hg vapor is continuously released from amalgam and absorbed by the lungs. Furthermore, chewing and abrasion, brushing, and increased temperatures strongly stimulate amalgam corrosion and the evaporation of Hg. Due to corrosion, Hg^{2+} ions and microscopic amalgam particles are also released into the saliva.[1,11,16,19]

Autopsy studies have demonstrated the presence of Hg in a variety of tissues including brain, kidney, thyroid, pituitary, skin, and blood. Tissue specificity appears to be related to the specific chemical form of Hg. Thus, the central nervous system appears to be the primary target of the lipid-soluble forms, namely elemental Hg and short-chain alkyl mercurials, while the renal proximal tubular cells are the primary target of the water-soluble forms such as mercuric mercury.[18,22]

In this investigation, we found no correlation between the existence of amalgam restorations and brain Hg level. The average Hg level of the amalgam group was 0.97 ± 0.83 μg/g, while in the amalgam-free group, it was 1.06 ± 0.57 μg/g. The brain mercury level of the amalgam group was slightly lower than that of the amalgam free control group. Our finding therefore does not verify other studies that reported that there was a positive correlation between the number of amalgam fillings and mercury level in the brain.[13,23,24]

Saxe et al.[21] also reported no significant correlation between exposure to dental amalgam and total Hg in the brain that may be due to the impact of MeHg in the diet, which was not considered.

Excluding occupational exposure, dietary intake is the most important source of Hg, besides dental amalgam restorations.[13,19] The World Health Organization (WHO) has reported that eating seafood once a week raises the urine Hg level to 5–20 μg/l, which is higher than the exposure from dental amalgam (1 μg/l).[14] Thus, when the contribution of amalgam fillings to body Hg levels is discussed, it is essential to consider the absorption of Hg salts contained in food. The MeHg found in fish is the most important dietary source of Hg. Björkman et al.[18] reported that in a fish-eating population, MeHg from the diet has a marked impact on total Hg concentration in the brain. Hg may also be present in certain drugs, contact lens solutions, cosmetics, and vaccines.[25]

Although autopsy studies are the most reliable studies for assessing Hg levels in tissues, they have some limitations, as does the present study. For instance, it is extremely difficult to estimate the contribution of

dietary intake and other Hg sources to total brain Hg level and total body burden. In the present study, each cadaver from both amalgam and control groups, during his or her life span might have had different dietary habits, occupations, or environments affecting Hg intake. For example, it has been reported that drinking alcohol, smoking, bruxism, age, hot drinks, acid food, and nasal or oral breathing affect Hg absorption rates from dental amalgam.[2,5,25,26]

The number of specimens is also generally restricted in autopsy studies due to difficulties in finding cadavers that have a certain number of amalgam fillings.[13,24] In order to minimize these limitations, multicentered, well-controlled, designed studies with larger quantities of specimens are needed for more reliable results. Well-designed animal studies may also be planned for minimizing occupational Hg intake under controlled and isolated laboratory conditions.

Another limitation of autopsy studies is the establishment of non-amalgam control groups. Specimens may have come from older cadavers, especially with missing teeth (total or partial) that had amalgam fillings during their lifetime. Also, it is nearly impossible to detect root amalgam fillings and amalgam restorations under dental crowns and bridges.[27] In our study, cadavers with teeth missing were included in the control group.

Despite their limitations, autopsy studies have made a valuable contribution to the debate on the hazards that amalgam poses to human health. The finding by the authors of the present study that there is no association between brain Hg level and amalgam restorations contributes to that debate and also suggests that dental amalgam is not a major contributor to brain Hg levels.

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