Dental amalgam is made by mixing approximately equal parts of elemental liquid mercury (43 to 54%) and an alloy powder (57 to 46%) composed of silver, tin, copper and sometimes smaller amounts of zinc, palladium or indium. This material has been extensively used as a tooth filling material for many decades (170 years). In the United States alone, the American Dental Association estimates that amalgam fillings have restored the teeth of 100 million Americans (1). Dental amalgam has, beyond doubt, saved millions of teeth that otherwise would have been extracted. The fact that dental amalgam contains and releases elemental mercury, concerns have been raised over the years with respect to its potential health effects to the dental personnel, the patient and lately to the environment (2). Amalgam is the most thoroughly studied and tested filling material in use. After decades of research projects undertaken around the world, no controlled studies have ever been published demonstrating adverse effects from amalgam fillings (3). Compared to other restorative materials, it is among those which have been regularly improved in terms of its mechanical properties and presentation. It is durable, easy to use, inexpensive and its longevity in a wide range of clinical application has been tested and reported to be 10-20 years with an average survival of 15 years (4). Despite the increasing use of tooth coloured materials with advantages of adhesion and aesthetics, amalgam is still one of the most widely used dental restorative materials (1). However, the anti-amalgamist claims that “sensitive” individuals can develop neurological disorders, various emotional problems, cardiovascular problems, collagen diseases and immunologic disorders. To support their argument, several tests have been used; breath, urine, blood, skin, stool, electro-dermal testing and air analysis (5-7). These tests have been found to be inconclusive due to the difficulties in demonstrating that the

Abstract:

Objective: To review the scientific evidence on the adverse effects of dental amalgam in adults.

Study design and method: The key words “adverse effects” and “safety of dental amalgam” were used to search for publications in peer reviewed journals on adverse health effects of dental amalgam.

Results: Forty three papers were accessed and reviewed. Several researchers have reported that mercury released from dental amalgam restorations have not been demonstrated to contribute significant systemic effects on the immune system or neurological diseases. The available scientific data are not sufficient to relate various complaints and mercury release from dental amalgam especially due to other sources mercury like fish consumption. Moreover there are no controlled studies that have demonstrated adverse effects on health from amalgam fillings. Remarkably, the literature reviewed stated that amalgam restorations remain safe.

Conclusion: There is no validated scientific evidence that dental amalgam causes adverse health effects in adults.

Key words: - dental, amalgam, safety,
source of mercury is from amalgam fillings or exposure from foods, water and air. It is, therefore, not known if the amount of mercury released from dental amalgam is enough to cause illness, even in the most exposed or the most sensitive minority of the amalgam-bearing population.

The Scientific Committee of the European Commission in 2008 concluded that dental amalgams are effective and safe, both for patients and dental personnel. It also noted that alternative filling materials are not without clinical limitations and toxicological hazards (8). This is supported by the World Health Organization (WHO), FDI World Dental Federation and United Nations Environment Program (UNEP) report on the Future Use of Materials for Dental Restoration (2) and the U.S. Food and Drug Administration (FDA) which stated that elemental mercury levels released by dental amalgam fillings are not high enough to cause harm in patients (9).

Material and Methods

The key words “adverse effects” and “safety” of “dental amalgam” in adults were used to search for publications from peer-reviewed journals and key dental organization statements, declarations and resolution. The abstracts of the listed papers in English were reviewed to determine the relevance of the articles to the topics. Using the online library of the University of Nairobi and the internet 43 relevant articles were downloaded and reviewed.

Results

Exposure to mercury from dental amalgam can occur during placement, removal and in function. The evaporation of mercury from amalgams is affected by several factors: the concentration of tin in the Ag-Hg (fA1) grains, which make up the matrix of the amalgam structure and are the main mercury-releasing phase (10), corrosion process (11), the atmosphere in which the amalgam is placed (12) the incorporation of indium into the triturated mercury or alloy powder (13-15), alloying a small amount of palladium with the alloy powder (16), alloy powder shape (17) among others. Ohmoto et al (18) examined the relationship between mercury content and mercury evaporation from amalgams during setting using high-copper amalgams single composition and admixed types (Table 1).

They further stated that most of the factors influencing the mercury evaporation from amalgam are incorporated during the alloy manufacturing processes. When preparing amalgam with more resistance to condensation, caution is needed to prevent irregularities and cracks by carefully monitoring the amount of mercury used in trituration.

In an earlier study, Haikel et al (19) demonstrated a significant direct correlation between Hg vapor concentrations in intra-oral air and the sizes of amalgam restorations during each procedure: removing, setting, and polishing although there was no statistic significant difference. It is important to note that no control group was used in this study and other factors may have affected the result. The amount of Hg released from the mouth during function has been reported to be 0.03 μg/day (20, 21). Björkman and Lind (21) showed that while the age of the amalgam and the amalgam type influence the extent of mercury release during the initial non-steady-state conditions, the steady-state value of mercury daily dose due to a single amalgam filling is 0.03 μg/day, which is well below the calculated threshold-limiting value (TLV) of 82.29 μg/day considered dangerous for occupational exposure in the United States.

The release of mercury from restorations in the mouth has been shown to be extremely slow. Berglund et al (22) found that the amount of mercury released from the oral cavity was time-dependent and reported that, the amount of mercury released with the time kept constant was almost independent of the pumping flow rate up to 8 litres per minute. In a later study (23), the same authors tested the release of mercury over a 24hr period under conditions that were as normal as possible (Table 1).

The estimated average daily dose of mercury vapor inhaled from the amalgam restorations was 1.7 μg. Jones (24) reported that it would take 1,680 years for a 0.65g amalgam restoration to lose all of the combined mercury based on the established rate of release. The very slow release of a very small amount of mercury from amalgam restorations can be put into perspective by the fact that a patient with 10 amalgam
surfaces in his/her mouth would have a mercury intake into the blood which would be only 2% (0.8 μg/day) of the World Health Organization's Acceptable Daily Intake (WHO ADI 40 μg/day) for mercury, with no adverse health effects (24, 25). Further Halbach et al (26) evaluated the internal exposure and absorbed dose of mercury related to amalgam (Table 1). They concluded that the estimates obtained are below the tolerable dose set by WHO. Therefore the amount of mercury released from amalgam restorations and absorbed by the body is minuscule and unlikely to cause adverse health effects.

The exposure to mercury vapor is of greater concern for dentists and their staff than for patients. Several researchers have reported that most people with fillings have less than 5 micrograms of mercury per liter of urine. Nearly all practicing dentists have levels below 10 micrograms per liter, even though they are exposed to mercury vapor when placing or removing amalgam fillings. Thus, even with that exposure, the maximum levels found in dentists are only slightly higher than those of their patients and are far below the levels known to affect health, even in a minor way (27-31). Hence based on this data and the WHO maximum acceptable daily intake with no health effects (ADI) of 40 μg Hg/day, a dentist could carry out 1000 amalgam procedures a week and keep within the WHO ADI limits.

Table 1: The findings of different investigations on evaporation of mercury from dental amalgam.

<table>
<thead>
<tr>
<th>Author /year</th>
<th>Population/sample</th>
<th>Investigation</th>
<th>Findings/Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haikel et al (19)</td>
<td>242 subjects</td>
<td>Analyzed the level of mercury vapor of intra-oral air before and after removing, setting and polishing dental amalgam using atomic absorption spectrometry.</td>
<td>Vapor was released during any procedure.</td>
</tr>
<tr>
<td>Berglund (23)</td>
<td></td>
<td>Mercury vapor released measured at intervals of 30-45 min using atomic absorption spectrophotometry.</td>
<td>Estimated average daily dose of mercury vapor inhaled from the amalgam restorations was 1.7 μg.</td>
</tr>
<tr>
<td>Halbach et al (26)</td>
<td></td>
<td>The integrated mercury absorbed from amalgam restorations - randomized controlled trial.</td>
<td>Reported estimates of up to 3 μg per day for an average number of restorations 7.4 μg per day for a high amalgam load.</td>
</tr>
<tr>
<td>WHO</td>
<td></td>
<td>Acceptable Daily Intake of mercury with no health effects.</td>
<td>WHO ADI 40 μg/day*</td>
</tr>
</tbody>
</table>

*Accepted daily mercury intake

Mercury is found in the earth's crust and is ubiquitous in the environment. Hence even without amalgam fillings, small but measurable blood and urine levels are found. Amalgam fillings may raise these levels slightly, but this has no clinical significance. The legal limit of safe mercury exposure for industrial workers is 50 micrograms per cubic meter of air for 8 hours per day and 50 weeks per year. Regular exposure at this level produce urine mercury levels of about 135 micrograms per liter. These levels are much higher than those of the general public but produce no symptoms and are considered safe (34). Other investigators, Kingman et al (35) (Table 2), Clarkson et al (36) and Brownwell et
al (37) have found no significant associations between amalgam exposure and clinical neurological signs or clinically evident peripheral neuropathy or other health effects (Bates et al (38) Table 2.

Some dentists and other health professionals advise people to avoid amalgam and to have their amalgam fillings replaced with other materials and taking vitamins and other supplements to prevent trouble after amalgam. "Amalgam toxicity" or "amalgam illness" has been diagnosed in patients who suffer from multiple common symptoms. Berglund and Molin (39) (Table 2) and Herrstrom and Hogstedt (40) found that patients and people with symptoms they related to amalgam fillings had no significant higher mercury levels in blood and urine than those of a control group.

Discussion

Table 2: The investigations on dental amalgam and its effect on health.

<table>
<thead>
<tr>
<th>Author</th>
<th>Population/sample</th>
<th>Investigation</th>
<th>Health effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ritchie, et al (25)</td>
<td>180 dentist against a control group</td>
<td>Well-controlled using a questionnaire the health and cognitive effects</td>
<td>Dentist report having a disorder of the kidney more than control group but the difference was not significantly</td>
</tr>
<tr>
<td>Svenden et al (32)</td>
<td>Dentist and dental nurses in Norway</td>
<td>Exposure level and mercury level in urine</td>
<td>Levels of exposure seemed low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urinary mercury concentrations</td>
<td>No significant association with reported memory disturbance</td>
</tr>
<tr>
<td>Kingman et al (35)</td>
<td>1663 dentate Vietnam veterans</td>
<td>Exposure to amalgam and its effect to clinical neurological signs, vibrotactile thresholds and peripheral neuropathy.</td>
<td>no significant associations between amalgam exposure and clinical neurological signs or clinically evident peripheral neuropathy</td>
</tr>
<tr>
<td>Bates et al (38)</td>
<td>20,000 Defence Force persons New Zealand</td>
<td>Association between amalgam restorations and disorders related with nervous system and kidney</td>
<td>No significant correlation between amalgam restorations and chronic fatigue syndrome or kidney disease was observed.</td>
</tr>
<tr>
<td>Berglund and Molin (39)</td>
<td>18 Patients referred physicians and control group</td>
<td>Any correlation between subjective symptoms and amalgam restorations- mercury levels in plasma, erythrocytes, and urine</td>
<td>The symptom group had neither a higher estimated daily uptake of inhaled mercury vapor, nor a higher mercury concentration in blood and urine than the control group.</td>
</tr>
</tbody>
</table>
tion of corrosive mercury salts that cause the skin to redden and possibly swell (5). The reaction is misinterpreted as a sign of mercury allergic reaction or toxicity. The other test used is hair which contains trace amounts of mercury from food, water, and air, regardless of whether the person has amalgam fillings. Because hair can absorb mercury from external sources, the amount of mercury it contains may not necessarily reflect the amount of mercury within the body. In addition, hair mercury testing cannot be standardized because hair thickness, density, shape, surface area and growth rate may vary from person to person. Further the laboratory reporting process has been stated to be invalid (6).

Autopsy studies are the most valuable and most important for examining the amalgam-caused mercury body burden. Guzzi et al (43) reported that total mercury levels were significantly higher in subjects with a greater number of occlusal amalgam surfaces (9) compared with those with fewer occlusal amalgams (0-3). They also stated that mercury levels were significantly higher in brain tissues compared with thyroid and kidney tissues in subjects with more than 12 occlusal amalgam fillings. Mutter (43) stated that dental amalgam is by far the main source of human total mercury body burden as proven by autopsy. This has, however, been disputed by the fact that humans are mainly exposed to methylmercury from seafoods and fresh water fish. This source of mercury exposure has not been controlled for by researchers who have reported amalgam as the main source of mercury exposure. Studies have shown even in the sick individuals who related their illness to mercury from amalgam (7, 38) their mercury levels in blood and urine was similar to those of the general population. Thus the alleged symptoms are common to other ailments, are self reported using questionnaires which have been found to be subjective and in some cases psychosomatic.

Conclusion
There is no validated scientific evidence that dental amalgam causes adverse health effects in adults even with the minimal amount of mercury released from it.

References
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