

The safety and domestic usage of amalgam in dental caries

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□ Background

Dental caries (i.e., cavities) is one of the most prevalent chronic diseases in the world. It is a type of bacterial infection, with complex causes. Dental caries occurs when tooth enamel—the milky and translucent hard outside layer of the tooth protecting tooth dentine—is damaged. The prevalence of dental caries on permanent teeth in Korean adults was 41.6% for men and 36.7% for women in 2007 and 36.5% and 28.9% for men and women, respectively, in 2013. The prevalence of dental caries tends to decrease as income levels increase. Dental caries is treated by removing the decayed part of the enamel, preventing the spread of decay by inserting into a tooth with a cavity, thus maintaining tooth function. Tooth filling materials are classified into metals, ceramics, polymer, and composite according to their characteristics, and filling techniques can be divided into direct and indirect methods according to the type of fillings. Tooth filling materials and methods are determined depending on the physical characteristics of materials, conditions of the dental pulp and dentine, the condition of periodontal tissues, appearance, treatment conditions, the size of defected area, dentist's proficiency, and mouth and body conditions.

Amalgam, a mixture of metals consisting of mercury, silver, tin, copper, and zinc, is an inexpensive material used as a dental filling and is covered by health insurance. However, it has a poor appearance, because the filled area turns black. The mercury included in amalgam for dental restoration is elemental mercury, and it is absorbed into the body in the form of mercury vapor. Patients and medical staff can be exposed to mercury vapor when tooth restoration is being completed using amalgam, or when it is removed. Because the elemental mercury affects the kidney and the brain, the

elemental mercury absorbed in the body can cause nephrotoxicity and neuropsychological disorders. Accordingly, as the issue of safety of the mercury contained in amalgam surfaced, the use of amalgam became a social issue.

Opinions on dental amalgam vary; people who are of the opinion that dental amalgam is harmful are of the opinion that mercury released from amalgam is excreted through urine every day, and this can affect a developing fetus through the placenta. They also argue that dental amalgam can trigger autoimmune reactions and lead to decreases in kidney or fertility function. Dr. Higgins, an American dentist, wrote in his book that mercury released from amalgam can cause chronic fatigue, disseminated sclerosis, hypotension, hypertension, tachycardia, lupus, leukemia, Hodgkin's disease, and Crohn's disease. Those who are against this opinion argue that mercury is detected in people who do not have amalgam fillings, because mercury exists in nature. ; moreover, there were no significant differences between the quantity of mercury detected in people with amalgam fillings compared with that found in people without amalgam fillings. Moreover, in studies that insist that amalgam is harmful, there was a tendency toward excessive measurements of mercury by making the study subjects chew gum before measuring the mercury levels.

Objective

This study was conducted to examine previous literature for the safety of amalgam and to identify the current status of usage of dental caries fillings in South Korea. Through this, it aimed to provide scientific evidence for the general public, relevant clinical experts, and policymakers involved in selection of dental caries fillings or establishing of policies.

Methods

1) Systemic Review

This study investigated domestic and foreign literature that reported the safety of amalgam in humans. Adverse events due to amalgam were

identified and characterized by performing a structured literature review using the systematic review method. After searching seven domestic and three foreign databases, study investigators evaluated literature published until July 2015, and literature was included without limitations on the publication period. More than two researchers independently made choices among the searched literature based on the preplanned selection/exclusion criteria.

2) Database analysis

The usage of amalgam and other fillings used in dental caries patients was identified by using domestic secondary data resources. The 2012 Korean National Oral Health Survey data was used to identify the exact current usage of dental fillings. This study requested the full data of patients of all ages who were treated for dental caries at least one time during 5 years from January 1, 2010 to December 31, 2014, based on the claims data of the Health Insurance Review & Assessment Service (HIRA). Health insurance subscribers and people subject to medical care were included.

Because the Oral Health Survey was conducted on children and teenagers, HIRA's claim data were analyzed to supplement these results. In the data, we could identify the filling usage of adults and filling usage trend by year.

Results

- Literature that reported on the safety of amalgam used internal mercury concentration, renal function, self-reported symptoms such as fatigue and pain, and the occurrence of diseases such as disseminated sclerosis and oral lichen planus as safety indices.
- Mercury concentration in people who have amalgam fillings was higher than that of people without amalgam fillings.
- Internal concentration of mercury varied depending on fish intake.
- When we compared the data published in Korea and overseas, there were no significant differences regarding the safety of amalgam.
- In the case of literature that targeted domestic populations, the internal mercury concentration was higher than for those studies performed on foreign populations.

1) Systemic Review

A total of 76 literature reports (20 domestic, 56 foreign) were selected through the structured literature review. The safety indices used in the literature reports can be classified into test results, diagnostic results, self-reported indices, and others. The test results can be classified into internal concentration of mercury and other contaminants, and mercury concentrations in urine, blood, hair, saliva, cord blood, amniotic fluids, and breath were measured. Besides this, neuropsychological testing, kidney function, hearing, and neonatal weight were included in the review of assessment studies. As for diagnostic indices, disseminated sclerosis, autism, oral lichen planus, and allergic reactions were reported. For self-reported indices, health-related indices such as pain and fatigue were used.

When amalgam was eliminated, internal concentration levels of mercury continuously increased until 48 hours.

Mercury concentration in people with amalgam fillings was higher than it was in those without amalgam fillings. Dose reactivity was not clear. Internal concentration of mercury also varied according to fish intake.

Neuropsychological indices including IQ and memory did not show any relevance to amalgam. In some studies, the results of people with amalgam fillings were better than that of control groups.

Oral lichen planus did show relevance to amalgam in case report. When amalgam was removed from patients with oral lichen planus, their symptoms improved.

There were not sufficient grounds based on the literature review to draw a conclusion on the safety indices, which included disseminated sclerosis, fatigue, and pain.

2) Database analysis

As of 2014, among the patients who filed claims for treatment of dental caries, 3,061,655 (47.2%) were men and 3,422,053 (52.8%) were women. These figures represent the number of patients who filed claims, and those who did not receive endodontic treatment or uninsured fillings—even if they had dental caries—were excluded.

The number of claim cases for amalgam was 2,963,399 in 2010; this number continued to decrease, and in 2014, 1,557,952 cases were claimed. On the other hand, in the case of capsule-type amalgam, 17,277 cases were claimed in 2010, and the number continued to rise every year, reaching 23,901 cases in 2014.

The number of claim cases for other insured fillings was 2,653,221 in 2010, and claims of this type have increased every year, reaching 3,572,269 in 2014 (filling types: glass ionomer 97.2%, composite resin 1.8%, metal reinforced cement 0.98%).

In the 2012 Korean National Oral Health Survey, 32.7% of the subjects had dental caries in milk teeth (i.e., deciduous teeth), and among them the number of women (67.9%) was about two times higher than that of men (33.3%). The rate of patients with dental caries in milk teeth was 15.4% for men and 14.4% for women. If we take a look at the filling rates of amalgam, esthetic materials and gold inlay, the majority of the patients chose esthetic materials (62.9%), followed by amalgam (37.0%), and gold inlay (0%). With regard to gender, the percentage of esthetic materials was the highest both in men (61.4%) and women (64.5%). Regarding age, the filling rate of esthetic materials decreased and amalgam increased with an increase

in age, and at the age of 15, amalgam was used in all milk teeth.

In milk teeth, dental caries was found in 40.7% of subjects, and the percentage of dental caries was higher among women (43.7%) than among men (37.9%). The percentage of dental caries in permanent teeth was 9.0% (men, 9.2%; women, 8.8%). Regarding materials used for filling, esthetic materials made up the majority, with 61.7%, followed by amalgam (24.7%) and gold alloy (13.6%). Also, as for gender, the use of esthetic materials was highest in both men (60.7%) and women (62.5%). The use of esthetic materials in dental restoration decreased and that of amalgam and gold alloy increased with age. In the case of monthly average household income, the use of amalgam filling decreased and that of esthetic materials and gold alloy increased along with increase in household income.

□ Conclusion

Amalgam has been widely used as a dental filling material for more than 150 years. However, its safety has also been a source of controversy. Although no clear health impairment has been observed, and despite its advantages over other fillings, the mercury content results in a negative perspective toward amalgam.

The study results indicated that mercury concentrations in urine and blood in people who have amalgam fillings were higher than in that of the control group. However, amalgam did not show a clear correlation with neuropsychological disorders and nephrotoxicity. Mercury concentrations in blood and urine in people with amalgam fillings also were below average levels. Therefore, there are no clear grounds to prove that amalgam is harmful to the body. In the case of South Korea, as a result of the first Korean National Environmental Health Survey, mercury concentration in blood was 3.08 $\mu\text{g/L}$, a level that was lower than the standard human biomonitoring (HBM) I concentration, 5.0 $\mu\text{g/L}$.

According to HIRA's analysis of claim data, there were no clear differences in the number of patients who made claims for dental caries and that of dental caries claim cases from 2010 and 2014. However, the number of amalgam-related claims is decreasing, and claims for esthetic materials are

increasing. This is thought to be because of esthetic reasons and concerns for safety.

People were exposed to the highest levels of mercury vapor of amalgam when restoring and removing amalgam. Therefore, the safety of oral health professionals such as dentists and dental hygienists also warrants consideration. In Norway, a report on the safety of amalgam exposure in dentists and oral health professionals was published in 2010. According to the report, internal mercury concentration and mercury concentration in blood of oral health professionals was higher than it was in the control group, and, in particular, mercury concentration was higher in dental care assistants than in dentists. Other safety indices showed no clear correlation, perhaps because of the small number of articles that are available in the literature. The use of capsule-type amalgam can minimize the mercury vapor exposure of oral health professionals.

Foreign opinions on the use of amalgam also vary. Amalgam is used as a dental filling in the United States, France, and Canada, and, although its harmfulness has not been clearly proven, dentists are directed to stop using amalgam in sensitive subjects, including children and pregnant women. Even the countries such as Norway that banned the use of amalgam did so out of concern for environmental impact rather than the direct risk posed to the human body. Other safety issues also are coming under the spotlight, such as the safety of resin conformer, an alternative for amalgam, as a result of bisphenol A contained in resin conformer.

Amalgam has been used as a dental filling for a long time and has some merits, with no clear grounds for establishing harmfulness; thus, its usage cannot be banned. The situation must be considered in the selection of dental fillings. However, mercury use is on the decline globally, and improper disposal causes environmental burdens. Therefore, when choosing amalgam, the use of capsule-type amalgam poses fewer burdens to the environment and can minimize the mercury vapor exposure of oral health professionals. Because mercury vapor is released when restoring or removing amalgam fillings, it is recommended that clinicians not restore or remove amalgam