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ORIGINAL RESEARCH

Evaluation of Mercury Contamination in Patients and Water during Amalgam Removal

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ABSTRACT

Aim: The aim of this study was to evaluate mercury levels in wastewater and in patients during the removal of dental amalgam restorations.

Materials and methods: To test for mercury levels, patients were tested before and after amalgam restoration removal. To test for mercury emissions, samples of constant volume of wastewater from high-speed drills were collected before and during amalgam restoration removal.

Results: Although the systemic mercury levels were lower than the limit of biological tolerance, all patients had increased levels after dental restorations. All samples of wastewater had increased mercury levels too.

Conclusion: The urinary levels of mercury increased with dental amalgam removal using a high-speed drill. During the process of amalgam removal, water used for cooling the dental drill was contaminated with mercury.

Clinical significance: The mercury released by the physical action of the drill, the replacement material and especially the final destination of the amalgam waste can increase contamination levels that can be a risk for human and environment health.

Keywords: Dental amalgam, Mercury, Dental materials.

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INTRODUCTION

Mercury has shown to be a heavy metal that can cause very serious damage to human health when individuals are chronically exposed to it. From the moment it enters the body, three chemical events occur, expressing its toxicity and future consequences: (a) Hg^{2+} reacts avidly with sulfhydryl groups of protein, causing a change in their three-dimensional structure, with a subsequent loss of biological activity; since Hg^{2+} is concentrated in the kidney during normal processing, this is the target organ that experiences the greatest intoxication; (b) with the mentioned three-dimensional change, some proteins become immunogenic, leading to a proliferation of B lymphocytes that produce immunoglobulins to bind to new antigens (tissues with collagen are particularly sensitive to this); and (c) forms of alkyl mercury, such as CH_3Hg^+, are particularly lipophilic and bind avidly to the proteins in tissues rich in lipids, such as neurons (myelin is particularly susceptible to breakdown by this mechanism).[1-3]

The system most affected, and that can bring about the most harmful results, is the central nervous system (CNS). The results include tremors, numbness, language disorders, abnormal reflexes, disturbances in nerve conduction, alterations in spelling, balance disorders, headache, pupillary reflex changes, memory disturbances, difficulties in concentration, and motor coordination problems.[4,5]

Mercury and its compounds have certain therapeutic properties, being used in medicines, such as laxatives, antihistamines, antiseptics and in silver-mercury amalgam in dental fillings.[4] Conventional dental amalgam is an alloy composed of 65% silver (Ag), 28-29% tin (Sn), 6% copper (Cu), and 1% zinc (Zn). Mercury was added to the alloy because of its ability to agglutinate fine particles, forming a metal alloy at room temperature.

It is believed today that the occupational route seems the most efficient for potential mercury contamination of the population.[6-9] Dental health professionals are also at risk of mercury contamination, bringing concerns regarding the handling of dental amalgam. Based on that risk, some European countries have restricted the use of mercury in dental offices. Sweden is a classic example.[10]

Combining these factors with environmental issues, Norway recently banned the production, import, export and

sale of products that use mercury-containing substances.[10] This has ultimately generated various forms of opposition to such action, and questions about the impact on the environment have been frequent because 50% of environmental contamination is from natural causes and another 42% is from burning fossil fuels.[11-14]

This study was carried out to evaluate the mercury potential contamination from amalgam over patients and wastewater from dental offices. For that purpose, patients were evaluated before and after the removal of old restorations and wastewater was tested before and during amalgam removal using high speed drills. The hypothesis of this study was that there were significant differences between patients and water before and after the amalgam removal.

MATERIALS AND METHODS

The total sample was composed of 10 patients, five women and five men aged between 20 and 40 years, who had an indication for replacement of amalgam by composite restorations in Black's class II cavities in upper or lower molars. The project was duly approved by the ethics committee, and all patients signed the informed consent form prior to taking part in any procedure of this study.

To evaluate patient mercury levels, urine was collected at the UNISUL Laboratory, University of Southern Santa Catarina from each patient immediately group patients before (GPB) the restorative procedure and 48 hours group patients after (GPA). Cold-vapor atomic absorption spectrophotometry (CVAAS) was used as a method for urine testing. The threshold limit value (TLV ≤ 5 µg creatinine) was used as a parameter, as proposed by the World Health Organization.[9]

Individuals that had previously reported some risk of additional exposure were excluded. Exclusion criteria sought to avoid any additional source of mercury exposure, including professional activity that could result in additional exposure to mercury, a diet rich in seafood, and use of cosmetics, especially hair dye.[4,5]

All restorations were removed by the same professional using a KaVo high-speed drill (KaVo Extra Torque, Kavo do Brazil Ind. Com. LTDA, Joinville, Brazil) under intense refrigeration with carbide burs compatible with the cavity size. Patients with teeth that did not allow a perfect seal of the operative field with a rubber dam (Lençol de Borracha-Angelus®, Londrina, Brazil) were also excluded.

All results were statistically compared using the Paired Student's t-test at 1% significance level for comparisons between dependent groups (GPB × GPA).

Patients who would remove old amalgam fillings were selected to analyze the potential for contamination of wastewater. A 5 mm^3 sample of water used for cooling the high-speed drill was collected before (control group) and during (test group) the removal of dental amalgam. That means it was wastewater that would go straight into the sewer. All patients received total isolation with rubber dam to prevent contact with saliva and incorporation of organic material.

A suction unit (Aspira Max, D-express, Curitiba, Brazil) was used to collect wastewater. A 0.05 mm diameter nylon net filter was attached to the end of the suction unit to prevent amalgam micro particles to be aggregated during the collection.

The waste water mercury levels were determinate by means of atomic absorption spectrophotometer with graphite furnace as a method. As a parameter was used the limit value recommended as standard by the environmental bodies, as proposed by the Brazilian National Environmental Council.[13,15]

All results were statistically compared using the Paired Student's t-test at 1% significance level for comparisons between dependent control and test groups (CG × TG).

RESULTS

Increased levels of mercury contamination were found in patients, as shown in Table 1. The results showed a statistically significant difference for the dependent samples GRA × GRB ($p = 0.009747$), regardless of the use of a rubber dam. Despite this, all results were below the biological exposure limit recommended by the WHO (1991).[9]

As shown in Table 2, the potential for contamination of wastewater containing mercury was statistically significant compared to the control group. It was observed that the simple removal of a certain amount of restoration, without any additional means of contamination, was able to produce

Table 1: Urinary levels of mercury found in the samples of patient group

Sample	*Absolute isolation*	
	Before (µg creatinine)	*After (µg creatinine)*
1	0.56	0.62
2	1.8	2.48
3	0.66	0.7
4	0.03	0.26
5	1.51	1.94
6	0.57	0.91
7	0	0.14
8	0.39	0.45
9	1.93	3.36
10	0.44	1.39
Mean	0.789	1.211
p-value	0.009746977	
Standard deviation	0.702415673	1.077192338
WHO (TLV)	≤5	

Table 2: Levels of mercury found in the samples of wastewater group

Sample	*Control group (mg/l Hg)*	*Test group (mg/l Hg)*
1	0	0.114
2	0	0.092
3	0	0.087
4	0	0.027
5	0	0.062
6	0	0.077
7	0	0.074
8	0	0.064
9	0	0.1
10	0	0.238
Mean	0	0.0561
Standard deviation	0	0.0935
p-value	p = 0.000514	
Maximum effluent standard (CONAMA)	0.01 mg/l Hg	

mercury-contaminated effluents beyond the limits recommended by the Brazilian National Environmental Council.

DISCUSSION

Mercury has shown to be a heavy metal that can cause very serious damage to human health when individuals are chronically exposed to it. Furthermore, mercury has been used because it has certain therapeutic properties, being used in medicines such as laxatives, antihistamines and antiseptics, and in silver-mercury amalgam in dental fillings. The conventional dental amalgam is an alloy composed of 65% silver (Ag), 28-29% tin (Sn), 6% copper (Cu), and 1% zinc (Zn). Mercury was added to the alloy because of its ability to agglutinate fine particles, forming a metal alloy at room temperature. In some cases, mercury can reach 50% of the mix.[14]

This study evaluated mercury contamination levels from dental amalgam under two perspectives: the patient and wastewater contamination. The conditions were controlled to perform a minimum exposure of both conditions evaluated. Even so, none of them were completely free of mercury.

Unlike Kremers at al[13] but corroborating the findings of Hylander et al[16] removal of amalgam fillings resulted in increased mercury levels during the first 48 hours after amalgam removal. Differently to Hylander et al[16] this research adds it occur regardless of the use of a rubber dam, a mechanical barrier used in clinical practice recommended to avoid the mercury contamination (*see* Table 1). Despite this it is essential to remember that all samples (*see* Table 1) showed mercury levels below the allowable limits for individuals not occupationally exposed too.[9]

This took place even in the case of a low exposure, since amalgam was substituted by composite restoration in all patients. It is known that mercury exposure can occur through direct contact with the skin, or in about 80% of cases, through the inhalation of its vapor, which is subsequently absorbed by the lungs. The latter is the most likely explanation for the ineffectiveness of rubber dam as a mechanical barrier.[15]

It should also be noted that there was great within-group variability in the incorporation of mercury. It is believed that this variability was due to the impossibility of determining the composition of the alloys used in the pre-existent restorations and lack of standardization of the volume of material to be removed. In addition, it is important to remember that all procedures were performed by the same professional who used the same equipment, and all patients were instructed to avoid any additional exposure to mercury, especially in the first 48 hours after the restorative procedure.

Pollutant load is characterized by a certain amount of pollutant transported or released in a recipient water body, expressed in mass unit per time. The release conditions are characterized by the emission standards for effluent control in the receptor body. It is precisely the release condition of mercury levels in wastewater produced during the cooling of high-speed drill in the clinical procedure for removing a dental amalgam that has been observed.

All samples in this case were contaminated. The concentrations were always higher than those recommended as standard by the environmental bodies (*see* Table 2).

Main reason for this occurrence included: (1) the volume of water collected (5 mm^3) served to standardize the sample volume, and was always obtained with the partial amalgam removal; (2) the inclusion of micro particles of amalgam was controlled; and (3) the restorations were replaced with mercury-free restorative material.

Therefore, it is believed that the amount of mercury from dental wastewater during a conventional restorative procedure, or total removal of the pre-existent restoration and placement by a new one, may be higher than that obtained in this study. In addition to the material released by the physical action of the drill, the replacement material and especially the final destination of the amalgam waste can increase contamination levels.

In healthcare services, the effluent infected with pathogenic microorganisms may only be released after special treatment. In the case of amalgam, collection units attached to the dental equipment are the main alternative.[16] However, they are not mandatory in all countries and when they exist, they depend on adequate filters and proper maintenance; otherwise it will have little effect on the contamination control of effluents.[10]

Finally, the relevant services rendered by the dental amalgam cannot be questioned.[14] However, it is understood that the controversy about the mercury and its impact on biosafety and environmental control, is posed. The effects

of the exposure to mercury from dental amalgam seem not so obvious,[17-19] but it could be possible to use procedures for mercury recovery from dental amalgam.[20] Another way to solve this problem could be repairing the amalgam restorations using composite resins.[21-25] When a part of the amalgam restoration and/or the cusp is fractured, that is a common problem, the professional could chose for repair this restoration instead of remove all of it.[21-25]

Further studies and broader discussions are recommended to assess the actual environmental impacts of this contamination and lead to safe clinical practices. Ecotoxicological testing to determine the deleterious effects of physical or chemical agents upon aquatic organisms is vital for human health.

CONCLUSION

According to the results obtained and analyzed in this study, it can be concluded that:

1. The urinary levels of mercury increased with dental amalgam removal using a high speed instrument. A rubber dam as a mechanical barrier was unable to prevent the increase in systemic mercury levels.
2. During the removal process of amalgam fillings, contamination of water used for cooling the system occurs. This water is discarded and may contaminate the sewage of dental clinics with mercury.

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