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Evaluation of mercury vapours release during amalgam restoration removal using facemask specimen and atomic absorption spectrophotometer: A pilot study

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Abstract

Objectives: Release of mercury from amalgam restoration and its subsequent toxicity has always been stimulating and vague at the same time. The most affected population remains the dentist and their aides due to continuous exposure to the mercury. The present study was an attempt to calculate the amount of mercury released in the form of vapours during removal of amalgam restoration.

Materials and Method: A total of eighteen patients with nine each from maxillary and mandibular arch which required removal of amalgam restoration were taken. The operator's mask during the procedure was used for evaluation of mercury vapours using an

absorption spectrophotometer. A carrier solution was prepared using 10% hydrogen chloride and 0.5% sodium borohydride. The facemasks were dissolved to form solution of 1 ppm which was converted into 10, 20, 40 PPB. The mercury content of the prepared solution was displayed by passing of cathode ray.

Result: The mercury vapours released during removal was statistically significant in maxillary arch restorations (19.667±9.44) compared to mandibular arch restorations (5.197±2.69). The levels obtained were much higher than the safety standards.

Conclusion: Mercury vapours released during amalgam restoration are much higher than recommended and can be considered as occupational hazard.

Keywords: Amalgam restoration, Absorption spectrophotometer, Dental amalgam, Mercury vapours, Occupational hazard

Introduction

The silver amalgam restoration is still a prevalent practice and particularly in dental schools, the undergraduate students are primarily taught and use this in their curriculum. The dental amalgam used is composed of 50% mercury, 34.5% silver, 9% tin, 6% copper and 0.5% zinc by weight.[1] The primary purpose of mercury in the alloy is to bind the particles together to make the restoration strong and durable. For the longest time the use of dental amalgam has been woke of controversies due to toxicity of mercury.[2] Mercury has been shown to have affinity of proteins and amino acids.[3] The toxic effects are documented on liver, kidney and central nervous system.[4] However, the oral ingestion of mercury could occur during the placement of restoration, in that if the alloy has completely reacted to an inert stage, mercury released is far below the toxic standard.[5]

The advent of tooth coloured restoration has resulted in their preference over any restoration which appears artificial.[6] Thus, in this quest, the previously done, if any, amalgam restoration has to be removed using a high-speed drill. This will cause vaporisation and aerosol of mercury in the dental office posing a high risk for the clinician as well as all the other personnel. It has been observed that the mercury vapours inhaled in the clinics is absorbed rapidly in the lungs. This mercury is capable of passing through the biological membranes causing deposition in the body.[7] Although the mercury which is released in the dental setup has been estimated to be within the safety standards, a study done by a group of researchers in Sweden have shown that exposure of dental clinicians and their associates have symptoms of mercury toxicity despite the urine and air levels are not remarkably different than the controls.[8]

The facemask or surgical mask is the most practiced and easily available respiratory protection. The mask is a barrier against the respiratory infection by stopping the aerosol to enter from one to another. [9] This works both ways, from patient to dentist and from dentist to patients.[10] The face mask available/used in routine practice is made up a synthetic material. Usually, these masks are not so efficient in filtration capacity and do not reach up to minimum 95% required for respiratory protection.[11] Thus there are higher chances of mercury vapours to affects the clinician. Hence the aim of the pilot study was to identify the amount of mercury vapours settled on the facemask of the operator.

Materials and Method

In this pilot study, 18 patients were selected who required removal of dental amalgam restoration for reasons which included secondary caries or damaged restoration. The patients were informed about the procedure, and a written consent was obtained for the

same as per the declaration of Helsinki. The ethical clearance was obtained from institutional ethical committee approval notice no. IEC: ECR/21/GDC/CG/2022 dated 15/07/2022.

The sample size was calculated using a previous study sample keeping standard normal variate to be 1.96 (95% confidence interval). The formula used was N = (r+1) (Zα/2+Z1-β)2σ2/rd2 where r is equal to n1/n2, (n = sample size of individual group of previous study), Zα/2 is normal deviate for level of significance, β is type II error, σ is pooled standard deviation, d is difference of means of two groups.

The patients were divided into two groups of 9 each.

Group I: removal of restoration from maxillary arch

Group II: removal of restoration from mandibular arch

The operators who were removing the restoration were undergraduate students and post graduate residents of Department of Conservative Dentistry and Endodontics. The patients and the operator used standard protective gears which included disposable scrub gowns to reduce deposition of mercury vapours in aerosol form on to the patients and dental personnel. In addition to that the area requiring dental amalgam removal was isolated in the oral cavity using rubber dam and high-pressure suction to further reduce inhalation and aspiration of mercury vapours (Figure 1-A, 1-B).

The facemask used was a triple layered composed of non-woven fabric, pleated consisting of melt blown filter. The facemask has an elastic cord for the ears and a nasal adjuster. A high-speed dental handpiece with sterilized carbide bur was used for removal of amalgam restoration. A time of 10-15 minutes per patient was spent, continuous irrigation and ejector was used. The facemasks were removed after that, as per the standard sterilization protocols and deposited in a sealed plastic bag for examination (Figure 1-C). A control unused mask was used to test in case to avoid any confounding bias related to content of the facemask. The facemask samples were examined using an Atomic Absorption Spectrophotometer (LABINDIA AA 8000).

The masks were dissolved and assessed for mercury content using three different solutions. Digestion of sample masks was done by tearing them into small pieces. It was done in the following manner: for 1 gm weight, 10 ml hydrogen chloride and 2.5 ml nitric acid aquarazia solution was used (sample). The mixture was boiled for 15 min and was covered by watch dial glass. For solution preparation, 19 ml digested sample was mixed with 1 ml sulphuric acid and 50 microlitre potassium permanganate. Then a carrier liquid was freshly prepared using 10% hydrogen chloride and 0.5% sodium borohydride in plastic bottle.

Standard solution for curve was prepared using 100 ml distilled water where 100 microlitre mercury was micropippeted from the sample prepared to form a solution of 1 ppm which was converted into 10, 20, 40 PPB by dilution of distilled water along with carrier liquid (Figure 1-D). In the second bottle 1 gm potassium permanganate was mixed in 100 ml distilled water to convert it into to 50 microlitre solutions. This solution was contacted with argon gas. Then it was studied in absorption spectrophotometer, the machine was switched on resulting in sucking of prepared solution, this was done in cold vapour mode. Cathode rays passed through the vapour and detect mercury concentration and reading was displayed in PPB. The data obtained were charted in an excel sheet. Since the comparison was done in maxillary and mandibular arch, the data was subjected to unpaired t test for statistical analysis using SPSS version 26.0.

Result

The concentration of mercury vapour obtained in the facemask samples (in ppb) is expressed in table I. On comparison of the two groups there was statistically significant difference where the concentration of mercury was found much higher in maxillary restorations than the mandibular group (table II and graph I). The level of mercury was found negligible for the control mask thus it was not taken in consideration. A mean value of 19.667±9.44 was found in group 1 with highest value of 30.2 ppb while mandibular teeth showed a mean value 5.197±2.69 of while highest recorded value was 9.1 ppb.

Discussion

The literature is conflicted on the amount of toxicity caused by dental amalgam restorations however the effect of mercury vapours has been strongly associated with toxic reactions in the body. The mercury vapours are mostly metallic mercury which are absorbed in the lungs at 80% efficiency thus forming the major risks for mercury toxicity.[5] Although mercury does not stay in the body and eventually passes out but the deposition around the tissues before it is finally eliminated could be a concern. Numerous studies have been conducted to determine a safe level of mercury exposure but the levels have been changed over the years thus the literature is blurry on the effect of mercury vapours on dental personnel and their safety.[12] The National Institute for Occupational Safety and Health has accepted a limit of 0.05 mg/m3 averaged over 8-hour work shift over a 40-h workweek.[13]It has also been proposed that the amount of mercury vapours release increases upon stimulating; the dental handpiece generating a high temperature during removal can increase this release substantially because of the friction and heat[14] hence increasing the risk.

The method of quantification of these vapours has been delineated by OSHA for vapours as well as particulate matter of mercury.[15] For mercury vapours, a sampling device could be used to assess the levels of atmospheric vapours.[12] Thus, for the present study, facemasks were used as samples. The facemasks which were used can only provide an estimate of the mercury vapours which were released in the environment and got deposited on the facemask of the operator. However, this amount of vapours is not the sum total of the actual vapours released but only a partial amount which was excluded from the inhalation by all the personnel which were present at that time during the exposure phase. On examining the samples in the Atomic Absorption Spectrophotometer, the highest value obtained was 30.2 ppb for maxillary molar. Since this study is one of its kinds where a comparison was done for the maxillary and mandibular restoration and molars have been considered to avoid bias for both the arches. A consequently higher value has been obtained for maxillary arch with a mean value of 19.66 ppb while the mean of mandibular arch was 5.19 ppb, the difference was statistically significant. This is far above the permissible level. It is noteworthy that this level is achieved while the high-pressure suction and water coolant had been used during the procedure in a well-ventilated space. Therefore such a high value is of concern since as per literature use of saliva ejector can reduce the mercury vapours up to 1.5µm/m^3.[16] Rugg-Gunn et al have shown the level of exposure to be 0.19 mg/$m^3$when no irrigation or ventilation was used[17] while a study done by Silverio et al has shown a level of 4.91ppb and 291.25ng/facemask when irrigation and ventilation was used in a pilot study of eight samples.[18] The level of mercury present in the facemasks in the present study was much more than the values obtained in

these aforementioned studies. However, they have not compared the vapours of mercury formed in different arches. Thus, comparison of this pilot study to any previous literature was challenging. Another intriguing finding is the higher concentration of mercury vapours during removal of silver amalgam from maxillary arch which can be attributed to the patient position and its proximity to operators' mask. Premolars were not included in this study so as to avoid the difference in sizes of restoration.

The limitation of the study lies in the small sample size. This is a pilot study and is being further carried out with a greater number of samples. Another drawback is that the size of restoration is not considered for the present study and ways to eradicate and standardize the restoration is being tried by the authors. The facemask masks used in the current study do provide 80% efficiency [19] yet the amount of vapour inhalation (apart from that deposited on the mask) is controversial and uncalculated once the mask is removed by the operator after the procedure is completed. These factors should be adjusted and a study with larger sample size is warranted to establish the results obtained from this study.

Conclusion

The levels of mercury vapours obtained in the present are alarming as a health risk for the dental personnel. The samples have exhibited the vapours which were not inhaled thus the amount of vapours which were inhaled are far greater and concerning to the professionals. A standardized setting of all the involved factors which can minimize the risk and amount of exposure should be calculated to declare if the amalgam is an occupational hazard to our kind or not.

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Legends figures and tables

Table 1: Results obtained by the atomic absorption spectrophotometer of the mercury identification levels.

Sn.	Tooth Number	Mercury Concentration(ppb)
1	26	35.6
2	17	11.2
3	26	19.1
4	27	16.7
5	16	30.2
6	16	28.5
7	17	9.5
8	27	13.8
9	16	12.4
10	36	6.29
11	46	1.29
12	36	3.2

13	37	8.6
14	47	2.9
15	37	4.9
16	47	6.9
17	46	3.6
18	36	9.1

Table 2: Table showing mean comparison of mercury levels on the facemask during amalgam restoration removal from maxillary arch and mandibular arch

Group Statistics								
	Group	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	T	P value
Mercury Concentration (in ppb)	Maxilla	9	19.6667	9.44881	3.14960	14.468	4.418	0.001*
	Mandible	9	5.1978	2.69435	.89812			

Graph I: Graph showing mean comparison of mercury levels on the facemask during amalgam restoration removal from maxillary arch and mandibular arch

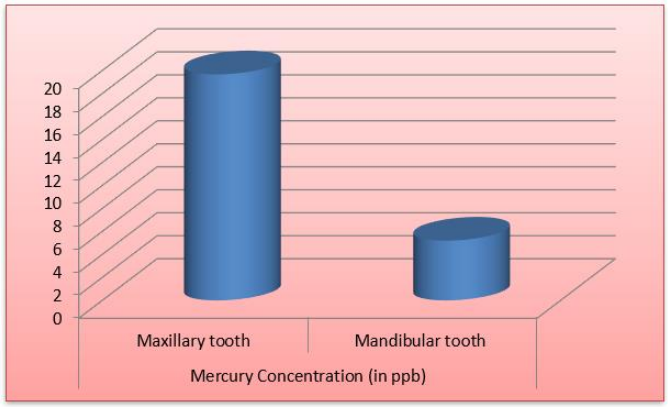

Figure 1: A –Dental amalgam restoration with respect to 46, B- After removal of restoration, C – Used facemask in plastic bag, D- Preparation of carrier solution and dissolution of facemask for spectrophotometer.

A. Dental amalagam restoration with respect to 46

B. After removal of restoration

C. Used Facemask in a plastic bag

D. Preparation of carrier solution and dissolution of facemask for spectrophotometry