ORIGINAL RESEARCH PAPER

Volume - 13 | Issue - 10 | October - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

EVALUATION OF EFFECT OF VARIOUS CHEMICAL AGENTS ON ELEMENTAL MERCURY RELEASE FROM HIGH COPPER AMALGAM - AN INVITRO STUDY

Dental Science

Dr Prathima B J* MDS, Assistant Professor, Dept Of Conservative Dentistry And Endodontics *Corresponding Author

Ayushi BDS student, Dept Of Conservative Dentistry And Endodontics

Dr Rupali Karale MDS, HOD & Professor, Dept Of Conservative Dentistry And Endodontics

ABSTRACT

Dental amalgam, used in dentistry for about 150 years, has been praised for its effectiveness but also scrutinized for its mercury content. X-ray fixer solution effectively prevents mercury vapor release by converting elemental mercury into less active mercuric sulfides. In this study, 88 samples were divided into four groups: Group 1 (Sodium Thiosulphate), Group 2 (Copper Sulphate), Group 3 (Calcium Chloride), and Group 4 (Potassium Iodide). Mercury content in each sample was measured on the 1st and 30th day using an ICP-AES method.After 24 hours, Potassium Iodide exhibited the lowest mercury content, followed by Sodium Thiosulphate, Calcium Chloride, and Copper Sulphate. After 30 days, Calcium Chloride showed the lowest mercury content, followed by Potassium Iodide. Despite the study's limitations, Potassium Iodide and Calcium Chloride are considered effective and safe alternatives for amalgam disposal over 30 days.

KEYWORDS

Dental Amalgam, Sodium Thiosulphate, Potassium Iodide, Calcium Chloride

INTRODUCTION

Dental Amalgam, a versatile and enduring material used in dentistry for about 150 years, has been celebrated for its efficacy and scrutinized for its composition.[1] The inclusion of mercury serves as a binder, facilitating the amalgamation process and imparting plasticity to the mixture, allowing for easy manipulation and placement within dental cavities. The widespread use of dental amalgam can be attributed to its numerous advantages in clinical practice. Its high compressive strength makes it well-suited for load-bearing restorations in posterior teeth, where chewing forces are greatest. Additionally, its longevity and resistance to corrosion ensure durable restorations that withstand the rigors of daily oral function. Moreover, dental amalgam is cost-effective compared to alternative materials, making it accessible to a wide range of patients, particularly in resource-limited settings.[2]

When aesthetics is not a priority, it can be used across all age groups, in stress-bearing areas, as a foundation for cast-metal and ceramic restorations, and in situations with poor oral hygiene.

However, amidst its long-standing utility, questions regarding its safety due to its mercury toxicity, environmental impact, and ethical considerations have sparked contentious debates within the scientific community and beyond.[3]

Dental offices are known to be one of the largest users of inorganic mercury which, if not handled and disposed through scientific methods, can pose grave threats to the biosphere.[4] Thus, X-ray fixer solution is evidently effective in stopping the release of mercury vapor, as it transforms elemental mercury into less active mercuric sulfides. [5]

However, the problem with the fixer solution is that the constituent Sodium thiosulfate can contribute to environmental pollution. When released into water bodies, it can affect aquatic ecosystems. Direct contact with sodium thiosulfate can cause skin, and eye irritation and allergic reactions in some individuals.[6]

Although the above-mentioned points are related to health but the percentage of deactivation of mercury and the duration of storage of disposed amalgam scraps under fixer solution remains unknown as there is a lack of dental literature support. Other chemical agents used for mercury detoxification are used in chemical industries such as - Vapor suppression agents containing Sulphur powder, copper sulphate, calcium chloride, potassium iodide, and propylene glycol solution which are considered to be effective.[7]

Hence the present study aimed to evaluate the effect of various chemical agents to eliminate elemental mercury from high copper amalgam.

The null hypothesis stated that there would be no difference in the elimination of elemental mercury from high copper amalgam using various chemical agents.

MATERIALS AND METHODOLOGY

The sample size was determined using G power software V.3.1.9.2. Considering the power of study at 80% and α error at 5% the total sample size obtained was 88.

Group Distribution[Each group n=22]

Group 1: Experimental sample exposed to 0.1M Sodium Thiosulphate ($Na_2S_2O_3$).

Group 2: Experimental sample exposed to 0.1M Copper sulphate ($CuSO_4$).

Group 3: Experimental sample exposed to 0.1M Calcium Chloride ($CaCl_2$).

Group 4: Experimental sample exposed to 0.1M Potassium Iodide (KI).

Sample Preparation

High copper amalgam was obtained by weighing 2g alloy and 2g mercury by trituration and 0.1M of chemical solution was prepared using 100ml of distilled water.

Chemical Exposure

Experimental samples were exposed to the different chemical agents (0.1M solution of sodium thiosulphate solution, copper sulphate, calcium chloride, potassium iodide) for 30 days consecutively.

Mercury Measurement Post-exposure

After exposure to chemical agents, mercury content in each sample was measured on the 1st day and the 30th day using an Inductively Coupled Atomic Emission Spectrometer.

Statistical Analysis

The following non-parametric tests such as Friedman's ANOVA, and Wilcoxon sign rank were applied. Each test was performed using SPSS VERSION 17 with a 5% level of statistical significance.

RESULTS

Table 1 summarizes the amount of mercury deactivation in different chemical agents exposed at 2 different time intervals. At 24 hours of exposure, KI showed least mercuric content in the solution (0.4341ppm) among the groups, whereas mercury content in other agents such as $Na_2S_2O_3$ (1.7341), $CaCl_2$ (1.7391) and $CuSO_4$ (52.795) was higher which was statistically significant. At 30-day intervals, $CaCl_2$ showed the least mercuric content in the solution (0.02677ppm) followed by KI (0.58550), $Na_2S_2O_4$ (1.3782), and $CuSO_4$ (9.5059) which was statistically significant.Table 2 summarizes pairwise comparison at 24 hours and 30 days. All the pairs- KI and $Na_2S_2O_3$, KI and $CaCl_2$, KI and $CuSO_4$, $Na_2S_2O_3$ and $CuSO_4$, $CaCl_2$, and $CuSO_4$ have given statistically significant values except for $Na_2S_2O_3$ and $CaCl_2$ pair which has given statistically insignificant values. All the pairs- KI and $Na_2S_2O_3$, KI and $CaCl_2$, KI and $CuSO_4$, $Na_2S_2O_3$ and $CuSO_4$, $CaCl_2$ and

$CuSO_4$ and $Na_2S_2O_3$ and $CaCl_2$ have given statistically significant values.

Table 1- Comparison Between Experimental Groups At 1-day And 30-day Intervals

groups	Sample size	Mean	Std. Deviation	Mean Rank	P value
GROUP 1-24HR	22	1.7341	.02364	2.45	<0.001
GROUP 2-24HR	22	52.795	.1889	4.00	
GROUP 3-24HR	22	1.7391	.01477	2.55	
GROUP 4-24HR	22	.4341	.01943	1.00	
GROUP 1-30day	22	1.3782	.01563	3.00	<0.001
GROUP 2-30DAY	22	9.5059	.06815	4.00	
GROUP 3-30DAY	22	.02677	.001510	1.00	
GROUP 4-30DAY	22	.58550	.008656	2.00	

p value by Friedman test
p<0.05 statistically significant

Table 2- Pairwise Comparison At 24hrs and 30 days

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.
GROUP 4-24HR-GROUP 1-24HR	1.455	.389	3.737	<0.001
GROUP 4-24HR-GROUP 3-24HR	-1.545	.389	-3.970	<0.001
GROUP 4-24HR-GROUP 2-24HR	-3.000	.389	-7.707	<0.001
GROUP 1-24HR-GROUP 3-24HR	-.091	.389	-.234	.815
GROUP 1-24HR-GROUP 2-24HR	-1.545	.389	-3.970	<0.001
GROUP 3-24HR-GROUP 2-24HR	1.455	.389	3.737	<0.001
GROUP 3-30DAY-GROUP 4-30DAY	1.000	.389	2.569	.010
GROUP 3-30DAY-GROUP 1-30day	2.000	.389	5.138	<0.001
GROUP 3-30DAY-GROUP 2-30DAY	3.000	.389	7.707	<0.001
GROUP 4-30DAY-GROUP 1-30day	1.000	.389	2.569	.010
GROUP 4-30DAY-GROUP 2-30DAY	-2.000	.389	-5.138	<0.001
GROUP 1-30day-GROUP 2-30DAY	-1.000	.389	-2.569	.010

p-value by Friedman test
p<0.05 statistically significant

DISCUSSION

The main issue of concern in the dental practice is the management of mercury as it is a toxic heavy metal capable of inducing a wide range of clinical presentations.[7] Proper management of mercury waste in dental practices is crucial to protect human health and the environment. It is stated by Environmentally Sound Management of Mercury Waste in Health Care Facilities that the use of effective chemical agents suppresses the action of mercury causing health issues.[7,8]

According to a study published by Chang et al,[5] lee et al[9] suggested that storing silver amalgam scraps and leftover mercury in X-ray fixer solution is more effective than water in preventing mercury vapor escape.[5] However, sodium thiosulfate present in the fixer solution causes environmental pollution and dermatitis when contacted.[6,7] Although the fixer solution is Considered as an effective agent in deactivating mercury, no studies state the storage time and concentration needed for mercury disposal.

So, there is a quest to search for alternative chemicals for mercury deactivation. This study employed use of Potassium Iodide, Copper Sulfate, and Calcium Chloride as alternative solutions because they are considered to be effective in mercury disposal in various chemical industries with fixer solutions as the control.[7,9,10] The mercury release from these solutions was assessed at two different timeframes with the concentration of each solution set at 0.1M for all the solutions is likely for standardization and comparison. This experimental design aligns with previous research by Bayram Yüksela et al. [11]

Literature cites several methods for detecting mercury including Cold Vapor Atomic Absorption Spectrometry (CVAAS), Cold Vapor Atomic Fluorescence Spectrometry (CVAFS), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS), all of which measure mercury levels with high sensitivity and specificity[12,13,14] Therefore, this study employed ICP-AES method (Inductively Coupled Plasma Atomic Emission Spectroscopy), which offers high sensitivity, a wide linear range, and minimal interferences with rapid and accurate measurements for various samples which is significantly more sensitive than other methods with detection limits as low as 0.2 µg/l with advanced instruments.[12,15]

At 24 hours assessment, Potassium Iodide (KI) demonstrated the least mercury content of all the solutions tested. This finding aligns with previous research done by Thomas Klasson et al., which explored KI's effectiveness in removing mercury from mixed waste. KI is known to replace other metal ions in amalgam, forming a less toxic potassium amalgam quickly.[16] At 30 days of assessment, the calcium chloride solution exhibited the least mercury content, as calcium ions reacted with mercury in the amalgam at the earliest time, decreasing its volatility[17] and making it safer for handling in dental practices. Thus, the null hypothesis is rejected.

As this is a preliminary study, future research should focus on variations in the concentrations of solutions to understand their impact on mercury disposal over different durations and under various pH and temperature conditions.

CONCLUSION

Considering the study's inherent constraints, it can be concluded that Potassium Iodide and Calcium Chloride are deemed safe and effective alternative chemical agents for amalgam disposal within 30 days.

REFERENCES

1. Ragavi RR, John BM, Jayakumar S, Sridhar DD, Arumugam K, Srinivas VC. Knowledge, attitude, and practice on mercury disposal by preclinical and clinical students of a dental college in Puducherry – A questionnaire survey. Indian J Dent Sci 2023;15:107-12.
2. Ramesh Bharti, Kulvinder Kaur Wadhwani, Aseem Prakash Tikku, Anil Chandra. Dental amalgam: An update. J Conserv Dent. 2010 Oct-Dec; 13(4): 204–208
3. Jan Aaseth, Bjorn Hilt, Geir Bjorklunde. Mercury exposure and health impacts in dental personnel. Environ. Res. J 2018;164: 65–69.
4. Raghuwar D. Singh, Sunit K. Jurel, Shuchi Tripathi, Kaushal K. Agrawal, Reema Kumari. Mercury and Other Biomedical Waste Management Practices among Dental Practitioners in India. Biomed Res Int. 2014; 2014: 272750
5. Chang C.Y et al. Stabilization of mercury-containing sludge by a combined process of two-stage pretreatment and solidification. J. Hazard. Mat. 1993;35:73-88
6. Sarfaroj Khan. Sodium Thiosulfate: Uses, Warnings, Side Effects, Dosage. Medical Reviewer 2022 (https://www.medicinenet.com/sodium_thiosulfate/article.htm)
7. Occupational Safety and Health Guideline for Mercury Vapor 2022 U.S. Occupational Safety and Health Administration, Washington, DC; (http://www.osha.gov/SLTC/healthguidelines/mercuryvapor/recognition. html)
8. Hussain Ali John, Shweta Sedani, Banning the Dental Amalgam–A Speculation to Review, J Res Med Dent Sci. 2022:10 (10): 118-120
9. Tai Gyu Lee, Yujin Eom, Chul Hun Lee, Kyung Su Song. Stabilization and Solidification of Elemental Mercury for Safe Disposal and/or Long-Term Storage, Journal of the Air & Waste Management Association. 2011;10(10):1057-1062,
10. Managing Small Mercury Spills- Fact Sheet, Health Care Without Harm Europe (Praha, Czech Republic) and Health & Environmental Alliance (Brussels, Belgium), October 2006. (http://www.noharm.org/europe/issues/toxins/mercury/resources.php)
11. Bayram Yüksela, Seda Kayab, Dilek Kaya-Akyüzlüb, Zeliha Kayaaltıb, Tülin Söylemezoglub. Validation and Optimization of an Analytical Method Based on Cold Vapor Atomic Absorption Spectrometry for the Determination of Mercury in Maternal Blood, Cord Blood, and Placenta Samples. At. Spectrosc.2017;38(4).
12. Brett I.Cohen, Bapanaiah Penugonda. Use of inductively coupled plasma-emission spectroscopy and mercury vapor analyses to evaluate elemental release from a high-copper dental amalgam: A pilot study. J Pros Dent. 2001;85(4):409-412
13. Mattigod, S.V, Feng X.D, Fryxell, G.E, Liu J, Gong M.L. Separation of complexed mercury from aqueous wastes using self-assembled mercaptan on mesoporous silica. J Sep. Sci. 1999;34: 2329-2345.
14. Lakshmi Narayana Suvarapu,Young-Kyo Seo, Sung-Ok Baek. Speciation and determination of mercury by various analytical techniques. Rev Anal Chem 2013; 32(3): 225–245
15. Tawfik A. Saleh, Ganjar Fadillah, Endang Ciptawati, Mazen Khaled. Analytical methods for mercury speciation, detection, and measurement in water, oil, and gas TrAC Trends in Analytical Chemistry. 2020; 132-116016
16. Thomas Klasson, Laurence J, Dianne D, Paula A. Removal of mercury from solids using the Potassium iodide/ Iodine leaching process. Oak Ridge national Lab publishers 1997 ORNL -27;3-96
17. Ye Zhuang, Jeffrey S. Thompson, Chris J. Zygarlicke, John H. Pavlish. Impact of calcium chloride addition on mercury transformations and control in coal flue gas. Fuel 2007; 86(15):2351-2359