Formulation and Evaluation of SilverAmalgum Use in Dentistry

Om S Bharane*[1], Amol V Sawale[2]
Vidyabharati College of Pharmacy Camp Amravati-444602 MH India

ABSTRACT: Silver nanoparticles (AgNPs) have emerged as promising agents in dentistry due to their antibacterial properties. This study aimed to formulate and evaluate silver nanoparticles for use in dental amalgam, focusing on enhancing its antimicrobial efficacy and mechanical properties. Various types of silver amalgam alloys were prepared, including low copper and high copper alloys, each with distinct compositions and setting reactions. The amalgam samples were subjected to testing to evaluate their strength, corrosion resistance, setting time, and biocompatibility. Results revealed that the high copper alloy exhibited superior strength and corrosion resistance compared to low copper alloys. The setting time of the silver amalgam wasdetermined to be 9.50 minutes. Biocompatibility testing indicated that while the silver amalgamwas generally biocompatible, it could potentially release small quantities of mercury. Overall, the study highlights the potential of silver nanoparticles in enhancing the performance of dentalamalgam, paving the way for improved restorative materials in dentistry.

KEYWORDS: Dentistry, Silver nanoparticles, Silver amalgam, Biocompatibility, Antibacterial Activity

INTRODUCTION

Since 1840, silver has been used in dentistry, primarily for the prevention and treatment of tooth cavities. It was first utilized as silver nitrate (AgNO3) and then in conjunction with fluorine (AgF)[1]. Silver began to be employed in restorative materials, such as silver amalgam, in the 2000s. The study of nano-materials gave rise to a new branch of the health sciences known as nanotechnology in the 20th century. The particles used in this new field were nano- metric in size, which changed the properties of biomaterials as usual and revealed new capabilities.[2]

Silver nanoparticles (AgNP), a type of metallic nanoparticle, have drawn particular attention in scientific studies because they exhibit antibacterial qualities and biological activity against bacteria, fungus, and enveloped viruses[3]. The release of cationic silver and its oxidative potential is primarily responsible for how AgNPs work. AgNPs' synthesis and mode of action can both be impacted by particle size and shape. Since some studies have embraced the technique of including antimicrobial chemicals in dental biomaterials, silver nanoparticles havetherefore emerged as a promising ingredient to be employed in dentistry[4].

Multiple drug-resistant bacteria have already been shown to be successfully treated using silver nanoparticles. However, there are now just three companies using silver nanoparticles (NP) commercially in dentistry[5].Dental glue Nano-Care Gold, DNTTM, Novaron AG300(Toagosei Co Ltd., Tokyo, Japan), and sealer (GuttaFlowTM Coltène-Whaledent) are all commercially available products that contain AgNPs. Therefore, the direct application of AgNPin dentistry would be intended to clean and guard against pathogenic bacteria in the oral cavity.These particles' primary application is based on their preventative effect[6]. The majorityof research that examined the use of silver nanoparticles in dentistry omitted information on either further commercial and clinical applications or the unique chemical properties of silver nanoparticles and their efficacy as therapeutic agents. As a result, in this study, technological advancements based on the development of silver nanoparticles in dentistry were examined. Additionally, we're eager to clarify the differences between the chemical, physical, and environmentally friendly processes utilized to create silvernanoparticles, as well as the many kinds of nanoparticles used in dentistry and how they work to combat both Gram-positive and Gram-negative and gram positive bacteria[7].

MATERIALS

Liquid mercury is combined with solid particles of copper, tin, and silver to create dental amalgam. Certain alloys contain trace amounts of zinc, mercury, and other metals. We refer to this mixture of solid particles as amalgam alloy.[8]The ISO Standard (ISO 1559) for dental amalgam alloy regulates the

composition of the alloy particles to regulate set amalgam qualities like corrosion and setting expansion. It's critical to distinguish betweendental amalgam and the amalgam alloy that is manufactured commercially and sold as spheroid particles, small filings, or a combination of these that can be mixed with liquid mercury to create dental amalgam.[9] The most typical uses of amalgam are in direct, long- term posterior restorations. An amalgamation reaction is the result of mixing mercury andalloy together.[10]A working mass that is silver-grey in colour and can condense intocavities will be the end product.[11] The dental amalgam condenses, is formed to produce the necessary anatomical features, and then gradually hardens. The amalgam alloy that was commonly composed before 1986 is known as conventional amalgam alloy. The compositional standard of the alloy has changed more recently (after 1986) as a result of improved knowledge of the links between structure and property for the various constituents. In contrast to the contemporary amalgam alloy, which is composed of silver (40%), tin (32%), copper (30%), and other metals, conventional amalgam alloy typically contains silver (~65%), tin (~29%), copper (~8%), and other trace metals.[12]

TABLE 1:- List of materials used in the manufacturing of dental amalgam.

Sr. No.	Low copper	High copper		
		Admixed		Unicomposition
	Lathe-cut or spherical	Lathe-cut	Spherical	Spherical
1.	Silver 63-70%	40-70%	40-65%	40-60%
2.	Tin 26-29%	26-30%	0-30%	22-30%
3.	Copper 2-5%	2-30%	20-40%	13-30%
4.	Zinc 0-2%	0-2%	0%	0-4%
5.	Mercury	-	-	1.5 - 2 times

METHODOLOGY

Safety Precautions:

- Wear appropriate personal protective equipment (PPE) including gloves, masks, andprotective eyewear.
- Ensure proper ventilation in the workspace to prevent inhalation of mercury vapor.
- Follow all safety guidelines and regulations set forth by relevant health andsafety authorities.

Preparation of alloy powder in various composition:

- Obtain high-quality silver alloy powder containing the desired percentage of copper. The alloy typically contains around 65-70% silver and 25-30% tin with the addition ofcopper.
- If necessary, pulverize the alloy into fine powder using a ball mill or similar equipmentto ensure uniform particle size distribution.[13]

Mixing of mercury in silver amalgam powder in appropriate concentration:

- Measure out the appropriate amount of mercury according to the manufacturer's recommendations. The ratio of alloy powder to mercury is typically around 1:1.5 to 1:2by weight.
- Dispense the mercury into a designated container, preferably one with a tightly sealed lid to minimize vapor release.[14]
- Place the measured alloy powder into a mixing capsule or bowl.
- Gradually add the measured mercury to the alloy powder while continuously mixing with a spatula or mechanical mixer.
- Mix the alloy and mercury until a homogeneous mass is achieved. The mixture should have a plastic-like consistency.[15]

Removal of mercury from silver amalgam by condensation method:

- Load the mixed amalgam into the prepared cavity using a suitable condenser.
- Condense the amalgam thoroughly to ensure complete adaptation and removal ofvoids or air pockets.
- Pay attention to proper condensation technique to achieve optimal mechanical properties and marginal integrity.[16]
- The excess mercury is removed with the help of muslin cloth.

Carving and finishing of cavity of tooth with silver amalgam:

- Carve and contour the freshly condensed amalgam restoration using appropriate carving instruments.

- □ Pay attention to anatomical form and proper occlusion.
- □ Finish the restoration by smoothing and polishing the surface using abrasive materialsand polishing agents.[17]

EVALUATION PARAMETERS: -

1) Strength.
2) Corrosion Resistance.
3) Setting Time.
4) Biocompatibility.

Strength Testing:

This test measures the maximum compressive load that a dental amalgam sample can withstand before failure. Samples are prepared according to standardized procedures. The compressivestrength is then calculated based on the applied load and the cross-sectional area of the 2g sample. Silver amalgam is weighed and calibrated on analytical weighing balance to zero. Then load is applied on top of sample silver amalgam and the maximum amount of load is calculated accordingto structural change of amalgam. Once the silver amalgam breaks down completely its compressivestrength is calculated.

Corrosion resistance: -

Dental amalgam samples are immersed in various solutions that simulate the oral environment, suchas artificial saliva or acidic solutions, for a specified period. After immersion, the surface of the samples is examined for signs of corrosion, such as discoloration or surface roughness. We have totake a acidic solution with pH less than 7. Then we have to keep dental amalgam in acidic solutionfor over time period of 12hrs. Then after 12hrs we have to check the dental amalgam. If it does notshow any changes then it is corrosion resistant.

Setting time: -

After mixing the dental amalgam components, gently touch the surface of the material with a gloved finger. Initially, the material will feel soft and pliable. As the setting progresses, the material will become firmer and less sticky. Once the material no longer feels tacky and your finger leaves a slight impression without sticking, it has reached its initial set.

Biocompatibility: -

Clinical observations: The primary concern regarding the biocompatibility of dental amalgam is itsmercury content. Mercury is known for its potential neurotoxic and nephrotoxic effects, particularly in vapor form. Biocompatibility test for silver amalgam is performed using saliva. we have to keep the sample silver amalgam in saliva for 24hrs .after that we have to take it out of saliva, if the silver amalgam shows any changes then the component of saliva does affects the silver amalgam which leads to its deterioration and if it does not show any changes then it does not affect silver amalgam.

RESULTS AND DISCUSSION

1. Strength:

Strength of high copper alloy is observed to be 145 gm/cm^2. The strength of dental amalgam is typically high, making it suitable for use in load-bearing areas of the mouth. Amalgam fillings can withstand the forces of chewing and biting over time. The test suggests the amalgam is under the guidelines of Indian dental association.

2. Corrosion resistance:

It was found that amalgam is corrosion resistance it does not reacts with the acidic solution whilein--vitro testing.

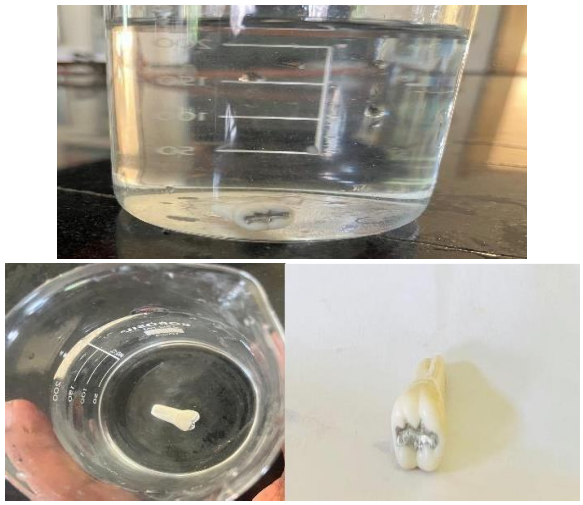

Image 1: corrosion resistance test in laboratory

5) Setting time:-

The setting time of the silver amalgam was obtained to be 9.50 min it takes 9 minutes and 50 secondsto solidify.

4.Biocompatibility:

Due to large no of metal content and mercury it can lead to staining and reaction with smooth musclefiber in the mouth to some people of the amalgam if not placed correctly.It was biocompatible but releases mercury in small quantity.

Image 2: Tooth cavity filled with silver amalgam

CONCLUSION

In conclusion, this study demonstrated the formulation and evaluation of silver nanoparticles for usein dental amalgam. The incorporation of silver nanoparticles into amalgam alloys showed promising results in terms of antimicrobial efficacy and mechanical properties. The high copper alloy exhibited superior strength and corrosion resistance, making it a favourable choice for dental restorations. However, concerns regarding the biocompatibility of amalgam, particularly the release of mercury, warrant further investigation and optimization of formulation techniques. Overall, the findings of this study contribute to the development of advanced dental materials with enhanced therapeutic and mechanical properties for improved oral health outcomes. Further research is needed to address the challenges associated with biocompatibility and to optimize the formulation of silver nanoparticles for safe and effective use in dentalamalgam.

ABBREVIATION

AgNP:- Silver nano particles ISO: Indian standard organizationAgNO3: Silver nitrate
AgF: Silver fluorine

REFERENCES

[1] Peng, J.Y.; Botelho, M.G.; Matinlinna, J.P. Silver compounds used in dentistry for caries management: A review. J. Dent. 2012,40, 531–541.

[2] Duran, N.; Marcato, P.D.; Conti, R.D.; Alves, O.L.; Costa, F.; Brocchi, M. Potential Use of Silver Nanoparticles on Pathogenic Bacteria, their Toxicity and Possible Mechanisms of Action. J. Braz. Chem. Soc. 2010, 21, 949–959.

[3] Gupta, S.; Jangir, O.P.; Sharma, M. The green synthesis, characterization and evaluation of antioxidant and antimicrobial efficacy of silver and gold nanospheres synthesized using wheat bran. Asian J. Pharm. Clin. Res. 2016, 9, 103–106.

[4] Lara, H.H.; Garza-Treviño, E.N.; Ixtepan-Turrent, L.; Singh, D.K. Silver nanoparticles are broad-spectrum bactericidal and virucidal compounds. J. Nanobiotechnol. 2011, 9, e30.

[5] Porenczukl, A.; Grzeczkowicz, A.; Maciejewska, I.; Goła´s, M.; Piskorska, K.; Kolenda, A.; Gozdowski, D.; Kope´c-Swoboda, E.; Granicka, L.; Olczak-Kowalczyk, D. An initial evaluation of cytotoxicity, genotoxicity and antibacterial effectiveness of a disinfection liquidcontaining silver nanoparticles alone and combined with a glass-ionomer cement and dentin bonding systems. Adv. Clin. Exp. Med. 2019, 28, 75–83.

[6] Brennan, S.A.; Fhoghlú, C.N.; Devitt, B.M.; O'mahony, F.J.; Brabazon, D.; Walsh, A.Silver nanoparticles and their orthopaedic applications. Bone Jt. J. 2015, 97, 582–589.

[7] Zhang, Y.; Zheng, Y.; Li, Y.; Wang, L.; Bai, Y.; Zhao, Q.; Xiong, X.; Cheng, Y.; Tang, Z.; Deng, Y.; et al. Tantalum nitride-decorated titanium with enhanced resistance to microbiologically induced corrosion and mechanical property for dental application. PLoS ONE 2015,e0130774.

[8] Jasso-Ruiz, I.; Velazquez-Enriquez, U.; Scougall-Vilchis, R.J.; Lara-Carrillo, E.; Toral-Rizo, V.H.; López-Castañares, R.; Morales-Luckie, R.A. Synthesis and Characterization of Silver Nanoparticles on Orthodontic Brackets: A New Alternative in the Prevention of White Spots. Coatings2019, 9, 480.

[9] Mittal, J.; Batra, A.; Singh, A.; Sharma, M.M. Phytofabrication of nanoparticles throughplant as nanofactories. Adv. Nat. Sci. Nanosc

[10] Yang, Y.; Ren, S.; Zhang, X.; Yu, Y.; Liu, C.; Yang, J.; Miao, L. Safety and efficacy ofPLGA (Ag-Fe3O4)-coated dental implants in inhibiting bacteria adherence and osteogenic inducement under a magnetic field. Int. J. Nanomed. 2018, 13, 3751.

[11] Charannya, S.; Duraivel, D.; Padminee, K.;

Poorni, S.; Nishanthine, C.; Srinivasan, M.R. Comparative evaluation of antimicrobial efficacy of silver nanoparticles and 2% 27chlorhexidine gluconate when used alone and in combination assessed using agar diffusion method: An in vitro study. Contemp. Clin. Dent. 2018, 9, S204–S209.

[12] Zhang, N.; Melo, M.A.S.; Antonucci, J.M.; Lin, N.J.; Lin-Gibson, S.; Bai, Y.; Xu, H.H.K. Novel dental cement to combat biofilms and reduce acids for orthodontic applications to avoid enamel demineralization. Materials 2016, 9, 413

[13] Besinis, A.; Hadi, S.D.; Le, H.R.; Tredwin, C.; Handy, R.D. Antibacterial activity and biofilm inhibition by surface modified titanium alloy medical implants following application of silver, titanium dioxide and hydroxyapatite nanocoatings. Nanotocixology 2017, 11, 327–338.

[14] Sasabe, E.; Tomomura, A.; Kitamura, N.; Yamamoto, T. Metal nanoparticles-induced activation of NLRP3 inflammasome in human oral keratinocytes is a possible mechanism of oral lichenoid lesions. Toxicol. In Vitro 2020, 62, e104663.

[15] Bacali, C.; Badea, M.; Moldovan, M.; Sarosi, C.; Nastase, V.; Baldea, I.; Chiorean, R.S.; Constantiniuc, M. The influence of grapheme in improvement of physico-mechanical properties in PMMA Denture Base Resins. Materials 2019, 12, 2335.

[16] Zhu, Y.; Cao, H.; Qiao, S.; Wang, M.; Gu, Y.; Luo, H.; Meng, F.; Liu, X.; Lai, H. Hierarchical micro/nanostructured titanium with balanced actions to bacterial and mammalian cells for dental implants. Int. J. Nanomed. 2015, 10, 6659–6674.

[17] Sasabe, E.; Tomomura, A.; Kitamura, N.; Yamamoto, T. Metal nanoparticles-induced activation of NLRP3 inflammasome in human oral keratinocytes is a possible mechanism of oral lichenoid lesions. Toxicol. In Vitro 2020, 62, e104663