Efficacy of Silver-Nanoparticles in PMMA - For Antimicrobial Effect a Systematic Review

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Abstract: ***Poly (methyl methacrylate) (PMMA) is a widely used polymer for dental applications, and it is mainly used in the fabrication of dental prostheses. In an increasing number of these applications,the risk of acquiring bacterial or fungal infection is higher than 60% among oral-prosthesis users. In the dental field, the formation of bacterial and fungal biofilms on prosthesis's surface is the etiologic factor for stomatitis, mainly caused by Candida albicans and bacteria such as Staphylococcus epidermidis, Staphylococcus aureus, Pseudomonas aeruginosa and Enterococcus faecalis, as well as many others. The antibacterial and antifungal properties of silver nanoparticles (AgNPs) have been widely reported, and their use in dental materials can prevent oralinfections, such as candidiasis and stomatitis, and promote better oral health in dental-prosthesis users. They can even be used in other biomedical applications that require controlling biofilm formation on surfaces. In this systematic review, the reported studies that use PMMA and AgNPs for dental prostheses are listed and checked, with the aim to gain a wider perspective of the application of silver nanoparticles in PMMA for its anti-microbial efficacy.***

Keywords: PMMA, Anti Microbial Property, Anti Mycotic Effect, Silver Nanoparticles, Graphene, Denture Base Material

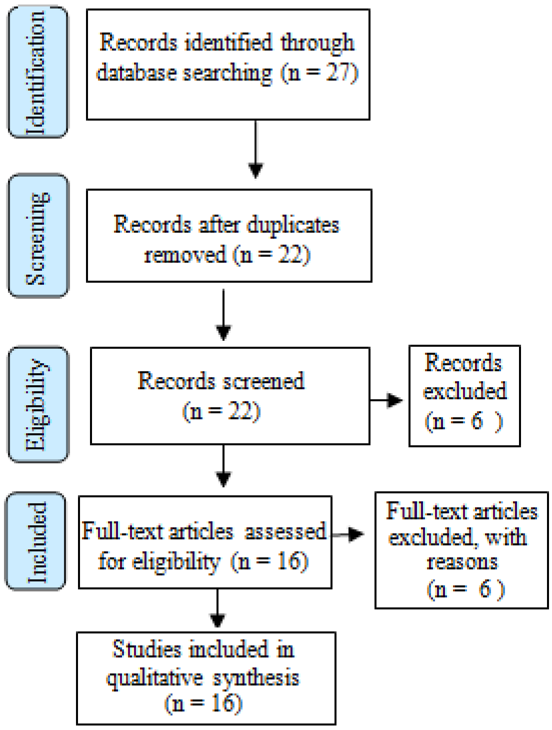
1. Introduction

Poly(methyl methacrylate) (PMMA) is a polymer used as a denture base material in dentistry;For biomedical applications, the evaluation of biological properties such as cytotoxicity, in vitro and in vivo biocompatibility, and antimicrobial effects provides essential information about the interaction between material and biological systems, which can be used for the development of new materials or new applications. In addition, the use of additives to improve the properties requires the modification of synthesis methods and evaluation of new properties relating to the resulting material. Silver nanoparticles (AgNPs) have been used in dentistry as an antimicrobial agent to prevent infections or colonization of biomedical devices by pathogenic microorganisms. AgNPs have been used to improve the mechanical properties of restorative materials and to inhibit colonization of dental prostheses' surfaces. The antifungal effect has been proved and has attracted great interest from researchers seeking to develop materials that can inhibit the growth of microorganisms that cause oral infections.

This review focuses on the use of AgNPs in dentistry. Synthesis methods and the antimicrobial effect are discussed. Our aim was to summarize the methods that uses PMMA and silver nanoparticles to promote an antimicrobial effect in dental prosthesis.

2. Methodology

To perform this systematic review, the data that were available from electronic databases were collected according to PRISMA recommendations for systematic reviews. The search of PubMed database was performed following the inclusion criteria. Full-text articles focused on the aim of this review,i.e., antimicrobial effect of silver nanoparticles and PMMA research articles published between 2010 and 2020 in peer-reviewed journals that include the keywords in their abstracts. Papers that focused on other research topics were excluded.



Prisma Flow Chart

Synthesis Methods

The reported methods in this review show that mixing AgNPs in monomer is the most frequently used method for synthesizing PMMA–AgNP for denture fabrication.Another reported method includes the use of solvents and specialized equipment to form PMMA modified with silver nanoparticles, such as dimethyl-formamide, oleic acid, N-methyl pyrrolidone and chloroform. This is done using a high-speed sonicator, as well as techniques such as cluster beam deposition and pulsed laser deposition.

Table 1: Synthesis method, Anti microbial properties of PMMA Ag Nano particles

S. No	*Author And Year*	*Synthesis Method*	*Anti Microbial Effect*
1	Acosta Torres et al, 2012	Mixing MMA monomer with AgNP suspension	Reduced Microbial adherence seen
2	Prokopovich et al, 2014	Encapsulating AgNPs with oleic acid and mixing with PMMA	Reduced Microbial adherence seen
3	Lyutakov et al, 2015	Dissolving AgNO3 with PMMA solution	Reduced Microbial adherence seen
4	Elashnikov et al, 2016	Mixing MMA monomer with AgNP suspension	Reduced Microbial adherence seen
5	Petrochenko et al, 2017	Pulsed laser deposition (PLD)	Reduced Microbial adherence seen
6	Zhang, Yu et al, (2017)	AgBr was added to the PMMA resin	Reduced Microbial adherence seen
7	Nunes de Souza et al, 2018	Mixing MMA monomer with AgNP suspension	Reduced Microbial adherence seen
8	Siddiqui et al 2018	Mixing PMMA adding AgNO3 solution	Reduced Microbial adherence seen
9	Slane et al 2018	Mixing monomer with AgNPs with ultrasonic mixer	Reduced Microbial adherence seen
10	Wekwejt et al 2018	Mixing monomer with AgNP suspension	Reduced Microbial adherence seen
11	Wook Yang et al, 2018	Poly methyl methacrylate (PMMA) resin containing silver at a concentration of 300–700ppm	Reduced Microbial adherence seen
12	Andri K et al 2018	immobilizing nAg and nano-hydroxyapatite (nHAp) on poly(methyl methacrylate)	Reduced Microbial adherence seen
13	Roshmi et al 2018	(PMMA) thin films incorporated with bio fabricated silver nanoparticles	Reduced Microbial adherence seen
14	Lisa et al (2018)	Polymeric matric incorporation with silver nanoparticles	Reduced Microbial adherence seen
15	Cecilia et al (2019)	PMMA WITH Graphene-Ag Nanoparticles	Reduced Microbial adherence seen
16	Matteis et al (2019)	Silver nanoparticles in PMMA.	Reduced Microbial adherence seen

3. Anti Microbial Effect

The use of silver nanoparticles can be considered a useful approach to increase the antimicrobial effect. Nunes de Souza et al reported that lower concentrations of silver nanoparticles can affect biofilm formation on PMMA surface, they also mentioned that the agglomerates of silver nanoparticles are more effective against C. glabratathan when nanoparticles are distributed individually. In case of Candida albicans, which is considered the major causative agent for stomatitis in denture wearers, Acosta Torres et al. in his study shows less adherence of C.albicans to the surface of PMMA–AgNP-based discs, suggesting an antifungal effect and the possibility that it acts as an anti-adherence agent for microbial colonization . Lyutakov et al. show that the use of silver-coated polymers can be a reliable approach for forming PMMA-based materials in treatment of bacterial colonization, he suggested that the release of silver ions can be an important mechanism that promotes antibacterial effect against Escherichia coli and S. epidermidis. Siddiqui et al. suggested that AgNP agglomerates showed reduced antimicrobial effect when used in higher concentrations(2wt %) compared with lower concentrations(1.5wt %), he conducted that the concentrations lower than 0.75 wt % had no well-defined inhibition zone in agar plates but when used in concentrations between 1 and 1.5 wt %, they observed positive results against Gram-negative and Gram-positive bacteria and also a positive antifungal effect.Elashnikov et al. formed light-activated PMMA nanofibers doped with photosensitizer meso-tetraphenylporphyrin (TPP), which has been reported as an effective reactive oxygen species (ROS) producer. TPP inactivates bacterial membranes upon light irradiation. The authors used an Ag/TPP/PMMA solution to prepare films by electrospinning. After this, the films were irradiated with a light-emitting diode light source (110 mW power output, 405 nm center wavelength and a light spot of 10 nm) and a 405 nm emitting laser system with 50 mW output. They evaluated the antibacterial effect using E. faecalis and S. epidermidismand reported that the light-activated PMMA nanofibers had a significantly increased inhibition zone compared with non-irradiated nanofibers. Light irradiation leads to the migration and release of AgNPs to the surface from nanofibers or to the formation of AgNP aggregates. The authors suggest that their obtained material is a promising option for the photodynamic inactivation of bacteria. This strategy is known as photodynamic therapy and has been used as a disinfection method in oral cavities.The antimicrobial effect of silver nanoparticles can be induced by the formation of ROS or by releasing silver ions from the material tested, depending on the synthesis method, silver-nanoparticle dispersion and silver concentration in the PMMA matrix. The studies reviewed here show the antibacterial effect of silver nanoparticles against Gram-positive and Gram-negative microorganisms and antifungal effects against different Candida species. According to the results of this review, the crucial factor for the antimicrobial function in PMMA is the additive. Some authors report the use of antibiotics to form bone cements that are used in orthopedic surgery to perform hip and joint implants. By itself, PMMA does not have antimicrobial properties, but by adding additives like silver nanoparticles, researchers are looking to design an appropriate material for dental prostheses,bone cement and other applications.

4. Conclusions

In this systematic review, we present an overview of the reported studies that use PMMA-based materials that were modified with silver nanoparticles for dentures fabrication. The use of silver nanoparticles as an antimicrobial agent for surface modification to prevent bacterial and fungal adherence can serve as an interesting approach to prevent oral infections in patients.According to the results of this review, the better strategy for embedding silver nanoparticles into a PMMA matrix seems to be mixing AgNPs with a monomer before the polymerization reaction. This strategy allows for control of some properties in areas that require improvement, such as nanoparticle concentration, shape and dispersion, depending on what kind of material is sought. This synthesis method is easy and simple to perform. Synthesis methods such as cluster beam deposition and pulsed laser deposition require more specialized equipment, which could be less efficient for synthesizing and obtaining the appropriate material. Standardized methods would allow us to compare materials in a more accurate way, and this fact can bring the development of materials with antimicrobial properties closer to their final clinical application in the dental field in the short term. For the success of dental applications at this moment, we need evidence from human clinical trials that this approach works appropriately. In recent years, with advances in the area of tissue regeneration and with new production methods such as 3D printing, the field of dentistry faces great scientific and technological changes. The use of PMMA–AgNP-based materials in dental applications can promote better oral health in prosthesis users, helping to improve their quality of life.

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