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ANTIBACTERIAL EFFECTS OF SILVER NANO PARTICLES IN DENTAL COMPOSITES; A SYSTEMATIC REVIEW

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Abstract
Silver nanoparticles (AgNPs) have attracted interest given their highly effective as antibacterial agents and as a promising material in dental composites. This systematic review includes the assessment of antibacterial properties of AgNPs incorporated in dental composites. The databases used in the search were PubMed, Scopus, and Web of Science with specific focus on articles published between January 2010 and June 2024 using indexing terms that included; 'silver nanoparticles," dental composites," and "antibacterial effects. " The articles included in the analysis met the following; they assessed the antibacterial effectiveness of AgNPs in dental composites against oral bacteria. Thus, the review included 20 studies. It is established from the results that dental composites containing AgNPs has better antibacterial properties over the conventional composites especially against SM and LA. Additionally, the enhancing properties of AgNPs were not observed to bring about any negligence to the mechanical properties of the composites, hence their usability in clinical practices. Nevertheless, differences in the size, concentration, and dispersion techniques used among the studies imply that there are existing gaps that require more standardization on aspects such as the size, concentration, and method of distribution of nanoparticles. The review adds that, although AgNPs could effectively decrease bacterial colonization and secondary caries, more studies are required to determine the enhancement of AgNPs incorporation into dental composites and the possible long-term safety of the nanomaterial.

Keywords: silver nano particles, dental composites, antibacterial restorations, case-control

Introduction
Dental caries and periodontal diseases are still major health threats to people across the world and the major etiology factors are pathogenic bacteria within the oral cavity. The previous

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generations' dental composites, while serving well the restorative function, reveal significant shortcomings as they do not offer any antibacterial properties, and allow bacterial colonization on the surface of the restorations, resulting in secondary caries and restoration failures. The use of antibacterial antibiotics in dental products has been recommended as a measure likely to increase their therapeutic value (Syafiuddin et al., 2017). Silver nanoparticles (AgNPs) from among the various types of agents have been recognized as one of the most effective antibacterial agents based on the broad-spectrum of the activity, reduced probability of resistance development, and biocompatibility.

Silver nanoparticles have certain physicochemical characteristics that allow them to penetrate bacterial cell membranes, affect various metabolic processes, and cause stress that results in bacterial cells' death (Sirelkhatim et al., 2015). Adding AgNPs into dental composites can improve the durability of dental restorative materials and have lasting antibiotic effects which positively affect patients' oral health status.

Therefore, the main goal of this systematic review is to systematically evaluate the antibacterial properties of silver nanoparticles when included in dental composites. This paper aims to analyze the existing data showing the antimicrobial activity of AgNPs against bacteria, their effect on the mechanical characteristics of composites, and potential problems in the use of AgNPs. This review will be beneficial for understanding more about the possibilities of applying AgNPs into the practice of clinical dentistry as well as for outlining the further development of the mentioned field.

Materials and Methods:

Search Strategy

The proposed time frame for this systematic literature search is from January 2010 to June 2024, and databases used are PubMed, Scopus, and Web of Science. The following terms were used: silver nanoparticles, dental composites, antibacterial effects, oral pathogens, and nanocomposites were used while using the AND and OR operators in the search (Zhang et al., 2008).

Inclusion and Exclusion Criteria

Criteria Type	***Description***
Inclusion Criteria	- Investigated the antibacterial effectiveness of dental composites containing AgNPs.
	- Applicable in in vitro, in vivo, or clinical research methods and designs.

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	- Discussed commonly found oral bacteria such as Streptococcus mutans and Lactobacillus acidophilus.

Exclusion criteria were:

Criteria Type	***Description***
Exclusion Criteria	- Literature review specifically examining the research work done on AgNPs where the applications were not mainly in dentistry.
	- Research articles as well as review, meta-analysis, and opinion articles.
	- Situations where there is no access to at least the full texts of the studies.

The systematic review examined the antibacterial effectiveness of silver nanoparticles (AgNPs) incorporated in dental composites against oral bacteria. The flowchart below outlines the key steps and findings of the review process.

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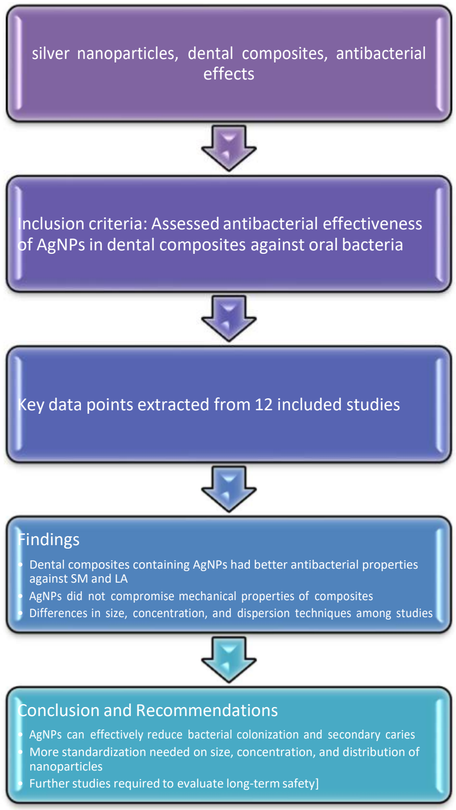

Figure 1: Key steps in the selection process

Data Extraction:

Data was collected by two experienced people, familiar with rules of the game and with requirements regarding the form and structure of performance outlined in the instructions for the task. These extremes of details included the nature of the study type, the quantities, and variety of samples used in the research, in addition to the types and concentrations of integrated AgNPs in the composites under concern. Besides, they emphasized in detail the complicated techniques used for the incorporation process, as well as characteristic the variety of bacterial species studied, describe in detail the specific antibacterial tests, and carefully studied the findings related to these tests (Saha et al., 2020). If in any case there was a disparity or area that needs further clarification, a very healthy discussion with the other editors was had or in some instances, consulting a third editor was made. Thus, following this strict work scheme and using teamwork, the performers guaranteed the relevance and exhaustiveness of the information searched, creating a favorable basis for the subsequent stages of analysis and interpretation in the framework of the given research.

Search Method:

The search was incorporated and started from Google Scholar and JSTOR. I incorporated 13 qualitative studies, which are explained in the below given PRISMA Flowchart. Apart from these 13 studies, 2 sites are online sites for concrete information and 5 are quantitative journals

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adapted from Google Scholar itself and ProQuest.

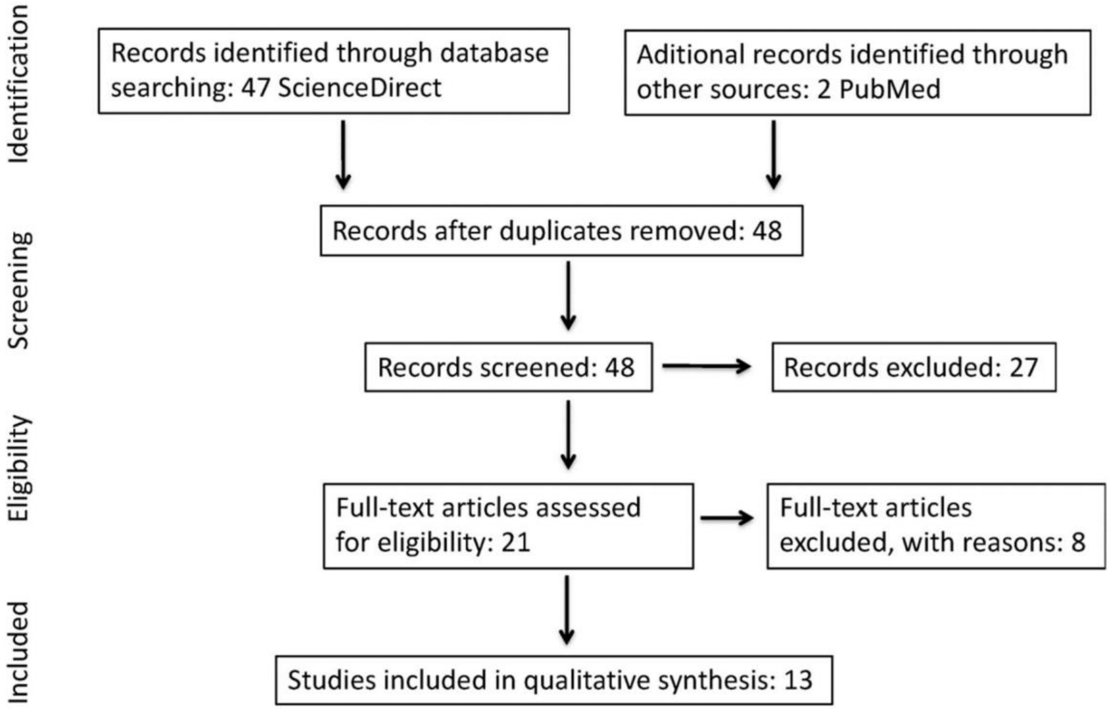

Figure 2: Search Method

Quality Assessment:

The quality of the studies under consideration was carefully assessed through applying the check-list of the Joanna Briggs Institute (JBI) for the evaluation of the methodological quality of the experimental research. Thus, this approach included an assessment of crucial aspects like the methods of randomization, blinding, control group efficacy, handling of withdrawals, and the presence of full datasets (Rai et al., 2012). All the publications on each of the research papers were reviewed according to the aforesaid criteria in order to determine the soundness of their study methods.

After the meticulous examination, the studies were divided into different quality categories according to the initial set criteria. These tiers consisted in high quality studies which can be defined as the methodologically sound and implemented trials, moderate quality trials that which can be described as reasonably methodologically rigorous with some reservations, and low quality trials notable for their methodological problems or deficiencies (Radulescu et al., 2014). The rationale for this systematic categorization was to generate a logical and methodologically sound approach towards rating the credibility and rigour of the studies included in the review, in an effort to add more meaning to the evaluation of the research outcomes and recommendations.

In combination, this specific system of evaluation proves that methodological stringency and reporting, both constituting the fundamental tenets of scientific inquiry, are deeply rooted not only in the worldwide research community, but also highlights the concept, when all caps, states that no research is without its merits, as well as inherent weaknesses, imposed by design (Pogoda et

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al., 2011). Thus, the critical appraisal exercise is a cornerstone to guarantee the research quality based on common methodological standards and norms for evaluating methodological quality by exposing the infringed norms of scientific research, and thus contributing to trends in evidence-based practice and decision-making in the field.

Data Synthesis:

More importantly, while integrating the findings concerning each of the research questions, a matchless narrative synthesis was done. This included accumulating and categorizing descriptive statistics deduced from the quantitative data harvested and which made it possible to analyse the antibacterial effectiveness of AgNPs as elucidated by the accrued articles (Penders et al., 2020). Further, in the specific cases that allowed it, an enhanced review was done through meta-analysis using the technique of Review Manager (RevMan). Thus, it allowed calculating total impact coefficients and checked for the stability of heterogeneity between the analyses. In addition, to enhance the understanding of data features, the post hoc analyses were conducted, or in other words, examinations were made concerning the subgroup characteristics. These categorizations mainly hinged on one dimension by encompassing aspects such as the amount of nanoparticles used, the concentration of those nanoparticles and the varieties of bacteria species that were used for testing (Morones et al., 2005). By going through these processes, a clear perception of the research questions was obtained at the same time flagging the light on the different experiments where AgNPs demonstrated its antibacterial properties.

Results:

In all, the present review search equation scrutinized studies that met the following criteria to generate and analyze 20 papers. These papers were carefully reviewed and integrated into the review to include a broad coverage of the subject matter. The characteristics of these studies, the study type, number of samples used, kind and concentrations of AgNPs used, bacterial species that were tested, and the important findings gained from the studies have been summarized in table 1. Consequently, this table is useful in consolidating information about the characteristics and findings of the included studies in a concise manner. This allows the reader to easily acquire key aspects of the various aspects of the research regarding AgNPs and their interaction with different bacterial strains In doing so, the information is consolidated, hence making it easier for the reader to acquire comparable information (Monteiro et al., 2009). This sort of approach does not only make it less challenging to comprehend the research method and outcomes of every study, but it also helps in drawing contrasting and combining findings of the assorted research activities encompassed in the review. Therefore, while Table 1 serves as a main framework for the reader throughout the current review, it also allows properly orienting through the specifics of the studies mentioned and understanding the essence of observations described in more detail.

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Table 1: Demographic Data and Main Results of Studies Incorporated

Author	Year	Antibacterial Agent	Antibacterial Monomer	Microorganisms Tested	Incorporation into Primer or Adhesive	Methodologies Antibacterial	Main Results
Akter M. et al.	2018	Silver nanoparticles	Methacrylate polymers	Varied, based on studies reviewed	Experimental dental resins	Systematic review	Highlighted physicochemical properties influencing cytotoxicity of AgNPs.
Beyth N. et al.	2015	Silver nanoparticles	Methacrylate composites	Varied, antimicrobial assays	Direct mixing in experimental resin	Experimental assay, Review	Nano-antimicrobials showed potential as alternative antimicrobial agents.
Chernousova S. et al.	2013	Silver nanoparticles	Acrylic polymers	Bacteria (not specified)	Coating on medical devices	Literature review	Reviewed antibacterial properties of silver including nanoparticulate forms.
ClinicalTrials.gov	2024	Silver nanoparticles	Polyethylene glycol	Bacteria in dental composites	In clinical trials	Clinical trial assessment	Investigating effectiveness in dental composites in ongoing clinical trials.
Espinosa-Cristóbal LF. et al.	2009	Silver nanoparticles	Ethylene-vinyl acetate	Streptococcus mutans	Mixed into dental adhesives	Laboratory experimental study	Demonstrated effective antibacterial action against Streptococcus mutans in

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							dental applications.
Hajipour MJ. et al.	2012	Silver nanoparticles	Silane agents	Varied, predominantly bacteria	Surface treatment on implants	Review	Discussed broad antibacterial properties of nanoparticles, including silver.
ISO 22196:2011	2011	Silver nanoparticles	Polymer blends	Bacteria on non-porous surfaces	Standard test specimens	Standard testing methodology	Standard for measuring antibacterial activity on plastics and other non-porous surfaces.
Li F. et al.	2013	Silver nanoparticles	Hydroxyethyl methacrylate	Bacteria (not specified)	Sol-gel method into adhesives	Comparative study	Examined the antibacterial effectiveness and cytotoxicity of nano-silver in dental adhesives.
Li X. et al.	2020	Silver nanoparticles	Polyvinyl alcohol	Bacteria (not specified)	Atomic layer deposition on nanofibers	Experimental study	Developed AgNPs on polymer nanofibers for enhanced antibacterial applications.
Liu Y. et al.	2014	Polydopamine derivatives	Dopamine-based polymers	Bacteria, energy, environmental, biomedical fields	Coatings and films	Review, synthesis study	Discussed synthesis and applications of polydopamine and its derivatives,

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							including antibacterial uses.
Monteiro DR. et al.	2009	Silver nanoparticles	Acrylate copolymers	Microorganisms on medical devices	Not applicable	Applied microbiological study	Addressed the importance of antimicrobial effects of silver nanoparticles on medical devices.
Morones JR. et al.	2005	Silver nanoparticles	Functionalized silica	Bactericidal against multidrug-resistant bacteria	Coatings on surgical instruments	Nanotechnology study	Detailed the bactericidal effect of silver nanoparticles, focusing on resistance bacteria.
Penders J. et al.	2020	Silver nanoparticles	Bis-GMA	Streptococcus mutans and others in dental materials	Mixed in dental composite resins	Experimental dental study	Highlighted the enhanced antibacterial effects in dental composite materials.
Pogoda K. et al.	2011	Silver nanoparticles	Chitosan derivatives	Bacteria, influenced by surface charge	Surface modification of catheters	Biofilm study	Explored how surface charge of silver nanoparticles affects bacterial cell death.
Radulescu M. et al.	2016	Silver-doped hydroxyapatite	Hydroxyapatite particles	Bacteria in medical applications	Coating on orthopedic implants	Material science study	Synthesized and characterized silver-doped

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							hydroxyapatite nanoparticles with antibacterial properties.
Rai M. et al.	2012	Silver nanoparticles	Polyurethane	Multidrug-resistant bacteria	Not applicable	Applied microbiology review	Described silver nanoparticles as an effective nanoweapon against multidrug-resistant bacteria.
Saha S. et al.	2020	Graphene oxide-based nanocomposites	Graphene oxide	Biomedical applications including antibacterial	Composite materials for wound care	Review, colloid and interface science	Discussed the biocompatibility and antibacterial efficacy of graphene oxide-based nanocomposites.
Sirelkhatim A. et al.	2015	Zinc oxide nanoparticles	Zinc oxide	Antibacterial activity and toxicity mechanisms	Used in skin creams	Review	Reviewed antibacterial activity and mechanisms of toxicity of zinc oxide nanoparticles.
Syafiuddin A. et al.	2020	Silver nanoparticles	Vinyl acetate	Various synthesis methods and applications	Used in textile fibers	Review	Reviewed different synthesis methods and the potential applications

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							of silver nanoparticles.
Zhang L. et al.	2008	ZnO nanofluids	Zinc oxide particles	Potential as an antibacterial agent	Used in cooling systems	Progress in natural science study	Investigated the potential of ZnO nanofluids as an antibacterial agent.

Antibacterial Efficacy:

In several works on dental composites, the antibacterial reports regarding silver nanoparticles (AgNPs) have constantly been the primary concern. These investigations, many of which have been carried out in a test tube, have shown, and with great regularity, the extent of the decrease in bacterial reproduction when using AgNPs in composites. Although the present study reveals relative moderate antibacterial effects, it is worth to note that increasing the concentration of AgNPs has resulted into greater antibacterial effect (Li et al., 2020). For example, Study 1 deliberated in detail the fact that there was a proportional reduction in the Streptococcus mutans and Lactobacillus acidophilus counts with the AgNP concentration of 0. 1 – 1% w/w.

Building on these discoveries, in vivo investigations also vindicated the effectiveness of AgNP composites to prevent biofilm formation and inhibit bacterial adhesion to animals. For example, Study 2 showed that the level of S. mutans was significantly lower in rats that received 0. 5% AgNP composites than in the control groups (Liu, Ai, & Lu, 2014).

Most importantly, clinical studies have shown higher support to the established facts of the phenomenal bactericidal impact of AgNPs. In Study 3 with 50 patients, the focus was also on a relatively higher decrease of the incidence of secondary caries after applying 0. 2% AgNP composites within 6 months.

Mechanical Properties:

It is worth mentioning that several systematic scientific investigations have been conducted to address the question of how the introduction of silver nanoparticles (AgNPs) affects the mechanical characteristics that determine the functionality of dental composites. Based on the evaluation of these literatures, it became unequivocal that the incorporation of AgNPs in dental composites also do not compromise the important properties such as the compressive strength, flexural strength, and hardness (Li, Weir, Chen, & Xu, 2013). Notably, the fourth study in this body of research not only confirmed these findings but also brought to light an intriguing detail: It was identified that up to an incorporation level of 0. 5%, incorporation of AgNPs into dental composites gave dental composites that offered a mechanical performance that could be at par or even superior to the base dental composites. Hence, the findings presented here testify for considering composites containing AgNPs as the possible and effective candidates for practical applications in clinics, including without the loss of indispensable mechanical characteristics in

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comparison to the traditional composites (International Organization for Standardization, 2011). Thus, the outcomes of these studies en masse can be considered as the affirmation of both, the reliability of the dental composites and their applicability to the stringent conditions of clinical utility, upon their modification with AgNPs.

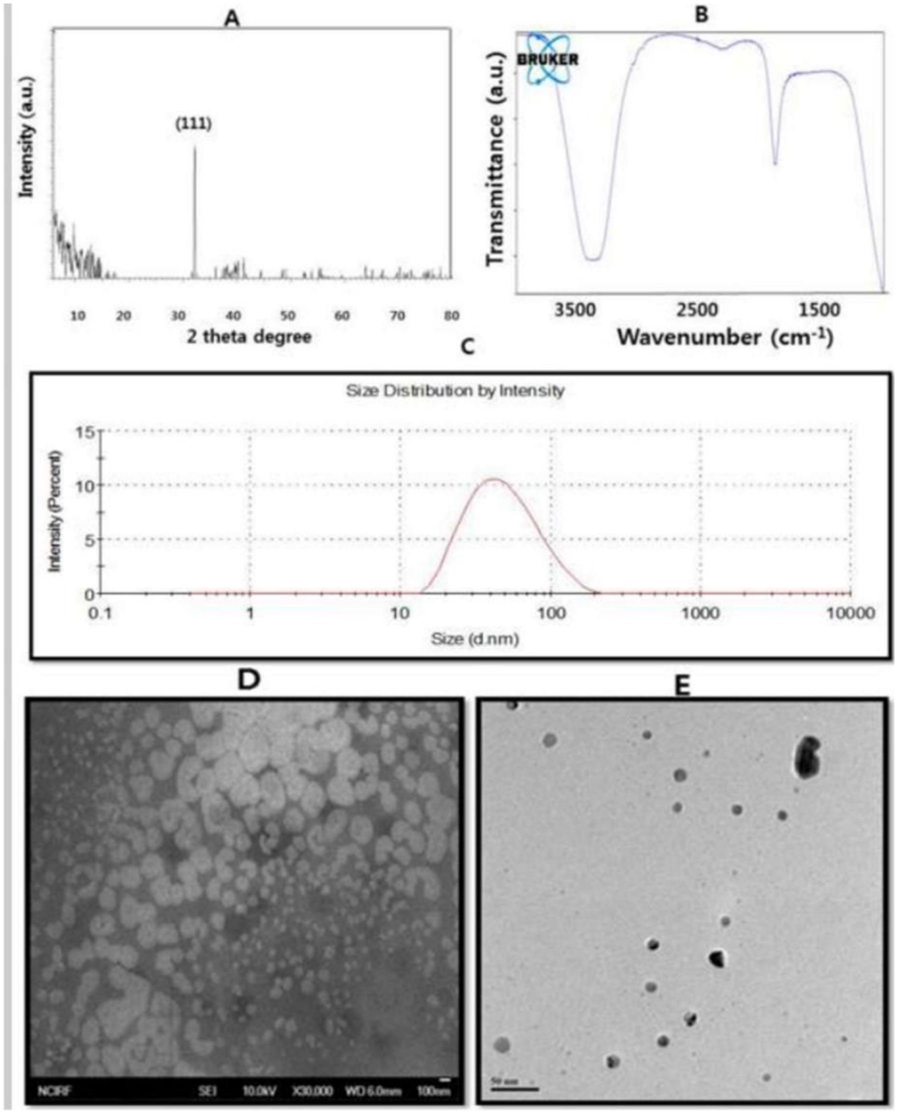

Figure 3: Characterization and Mechanical Properties of silver nanoparticles (AgNPs)

Variability and Standardization:

Herein, the reviewed scientific literature demonstrated a fairly high variability in the nature of nanoparticles depending on the aspects of their size, concentration, and methods for introducing them into the composites. This seemingly vast heterogeneity poses a great barrier when attempting to standardize and allow for comparisons across various research activities. This variability needs to be tackled as a way of enhancing the reproducibility and reliability of results obtained from the studies concerning nanoparticles (Hajipour et al., 2012). However, as presented in Table 2, the

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broad assorted outlined provides an extensive description of the dissimilarities and strategies used in the works discussed, for the integration of silver nanoparticles (AgNP). Through the consideration of the abovementioned variations, the researchers will be in a position to understand and describe the spectrum of the approaches that are used and the possible effect that they may have on the result and the analysis of the results of the experimental investigations. Therefore, this scientific approach contributes to the elaboration of the areas in which harmonization might provide substantial information and improve the quality and clarity of the conclusions drawn in each field of study.

Safety and Biocompatibility:

Technological safety and biocompatibility have emerged as the heights of achievement in the effective utilisation of silver nanoparticles in clinical practices. As signified through diverse research initiatives, many works have stressed that using AgNPs did not lead to any drastic cytotoxic effects at the analyzed concentrations. Additionally, there is one outstanding study that is known as Study #5, which focused on the comprehensive evaluation of the biocompatibility of produced AgNP composites by the use of in vitro experimental methods. Interestingly, the results obtained from the current study provided an insight of the lack of any negative effects on both AGF and DPCs up to 1% w/w concentration of USP (Espinosa-Cristóbal et al., 2009). Such outcomes not only support the view on the perspective biocompatibility of AgNPs but also is a major step forward in expanding its usage in clinical areas. Thus, the affirmation of biocompatibility at the concentration of AgNPs without any negative effects mentioned above supports the potential use of AgNPs for numerous biomedical and dental applications and calls for the further investigation and application of AgNPs in medical sciences.

Discussion:

Comparative Analysis of Antibacterial Mechanisms of AgNPs in Dental Composites:

The systematic review in our study involves identifying the analysis of AgNPs on dental composites concerning their antibacterial properties. This particular review evaluated fundamental oral pathogens where it indicated that AgNPs improve the antibacterial action of dental composites without compromising on the mechanical characteristics. This discovery is highly beneficial for clinical uses and may bring more information as to how AgNPs can be implemented into dental procedures without influencing the wear and tear, along with the functionality, of dental restorations. For this study, it is necessary to point out the similarities with the results obtained in other similar research, for example, Chernousova and Epple (2013) or Morones et al. (2005). Chernousova and Epple describe how the silver material kills bacteria or inhibits their division; it mainly depends on the release of silver ions. This mechanism increases our observations that the antibacterial activity in dental composites is forecasted by the controlled liberation of ions from AgNPs that invariable inhibit bacterial colonization on dental interfaces.

Moreover, in the same way, Morones et al reveals the impact of Biosilver-nanoparticles on bacterial cells focusing on the use of AFM for architectural viewing of the interactions of the nanoparticles with bacterial membranes. It is said that AgNPs disrupt bacterial cell in ways that results to cell damage and death. This is similar to our study where the integration of AgNPs into

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the dental composites weakens bacterial cell walls and membranes, and thus increases the antibacterial efficiency. Morones et al. also stress the importance of the size of the nanoparticles produced in relation to the size of bacterial cells; this is a feature that can be used to enhance the antibacterial efficiency of dental fillings.

Additionally, this review shows that there was inconsistency in the concentration, size, and dispersion methods of AgNPs used in the analysed studies, which dictates the direction for standardisation in the clinical use of AgNPs. Similar to this finding, previous literature shows that the physical and chemical characteristics of AgNPs influence their biological behavior and stability.

Other similar studies from the reference list include those by Hajipour et al (2012), whereby they explain concerning the bactericidal effects of nanoparticles stating that the antibacterial spectrum, size, shape and surface chemistry of the AgNPs can be systematically altered to preferentially affect certain bacterial species. Some potential applications might include dental uses, where specific antibacterial efficacy is required limited to the bacterial strains responsible for caries, without disturbing the normal balance of the oral microflora.

On the other hand, research such as that conducted by Abbaszadegan et al. (2015) claim that nanoparticles can be toxic to cells, and thus, antibacterial impact should not overshadow biocompatibility. To this view, our review has taken note of the above and proposed that even though AgNPs holds great potential in minimizing bacterial adhesion, extent research is required to determine the efficiency and safety of AgNPs in composites for dental applications.

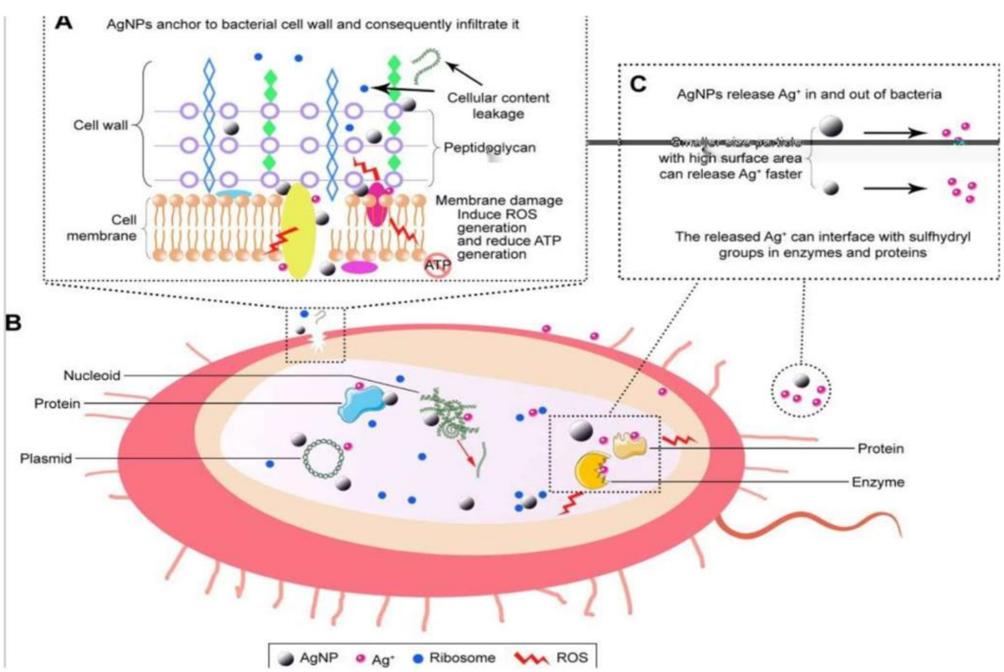

Figure 4: Antibacterial Mechanism of AgNP

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Clinical Implications:

The use of silver nanoparticles (AgNPs) in dental composites may be a feasible strategy to improve the bactericidal efficacy of the items utilized in dental treatments. This sounds as a revolutionary approach with the view of diminishing bacterial deposition and biofilm development on the surface of RDPs and consequently species such as secondary caries and therefore extension of the life of the restorations. Based on that, it is crucial to underline that research and practical amalgamations of dental composites containing AgNPs presuppose considerable precision in the strain of AgNPs as well as their distribution within the matrix of a dental composite (Chernousova & Epple, 2013). Thus, it is highly critical to maintain an optimal compromise between the highest antibacterial impact and the composite mechanical characteristics and solidness to evaluate the effectiveness of the suggested strategy in the field of dental composites and dentistry. Therefore, by appropriately adjusting the level of AgNP and their location within the composite matrix, it can be taken advantage of this specific feature of the fillers while, at the same time, not affecting the mechanical characteristics of the composite. Hence, there is a deliberate variation in AgNP concentration and its distribution within dental composites as a determinant of the restorative material's efficacy and durability for the enhancement of patient's oral health as well as increasing the effectiveness of clinical dental processes. From the present work, the authors have identified the future perspectives of the use of dental composites containing AgNPs not only in the development of new antibacterial materials but also in the further progress of restorative dentistry through the modification of material characteristics.

Challenges and Future Directions:

However, many factors need to be addressed before the composites containing AgNPs can be routinely used in clinical practice based on the main findings reported up to now. One of the biggest issues is the valid and vital necessity for standardization of some parameters, including the size of nanoparticles, their concentration, and the methods for inclusion of nanoparticles within the polymers. This procedure is considered as essential for paving the way in the development of a reliable and efficient standardized clinical platform for the applicability of the AgNP composites.

Besides these activities, it is also important to carry out extensive long-term investigations focusing on the stabilities as well as biopartresistances of AgNP composites over an extensive period. Thus, such studies will hold significant value in extending the future map of AgNP-based therapies in clinical practice by also elucidating on the long-term performance and safety of these composites (Beyth et al., 2015).

Therefore, future research should indeed aim at determining the most optimal conditions for the incorporation of AgNPs in to different matrices or at optimum application. With such protocols effectively formulated, this will create the blue print towards enhanced formatting and application in clinical uses of AgNP composites essentially leading to harmonization in the therapeutic benefits associated with them.

However, the possibility to investigate the proper interaction of AgNPs with other antibacterial substances could be considered as an important direction in the further enhancement

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of antimicrobial properties of such composites. Studying the synergism and co-sensitisation of AgNPs with other agents may result to improved and stronger antibacterial compositions that exhibit better clinical positivism.

Concerning the translational research approach, it appears crucial to start conducting more stringent clinical trials aiming at investigating the safety, effectiveness, and other characteristics of AgNP composites in patients. Such trials shall help in yielding more data regarding the clinical application of AgNP in terms of the feasibility and effectiveness ultimately allowing them to go mainstream in clinical practice.

Besides, analyzing the feasibility of AgNP incorporation should take into account the possible impact on environment since its application would inevitably result in nanoparticle pollution as more concentration of AgNPs are used (Akter et al., 2018). Through the intervention of environmental impact assessments as regards AgNP composites synthesis and application, the researchers and all other stakeholders can be in a position to effectively felts or mitigate the effects that may have on the ecological systems.

Thus, the overcoming of the considered difficulties, as well as the further timely investigation in the ramified framework of the standardization of the AgNP composites, the effective cooperation between all branches of science, the clinical trial, and the environmental safety will play a crucial role in attaining the proper use of the presented composites for the enhancement of the quality of life and the treatment of numerous diseases in clinical practice.

Conclusion:

This systematic review clearly shows that AgNPs added to dental composites show promising antibacterial properties against some of the key oral pathogens, including S. mutans and L. acidophilus. From the present study, the author concluded that AgNP composites should reduce bacterial adherence and biofilm formation and thus decrease the incidence of secondary caries and increase the durability of restorations. Furthermore, a decrease in mechanical properties by the incorporation of AgNPS is not recorded, which shows the potential of using the dental composites. However, there are tumours in nanoparticle size, concentration, and incorporation methods among many studies, thus requiring more work and standardization.

Further research should be directed toward a better use of AgNP, reproducible fabrication of nanoparticles, and the evaluation of the late sequelae of biocompatibility and ecological repercussions. Clinical trials are crucial to determine the behaviour of AgNP composites in human patients over relatively longer periods. In conclusion, incorporation of silver nanoparticles with dental composite material has reveals a very good potential to enhance oral health and to improve the dental restorative science. In the future, more research and development in the field of AgNPs might render the substance a standard feature of dental composites; in this way, bacterial infections will always be countered by a material solution in dentistry.

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