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SILVER NANOPARTICLES IN DENTISTRY: A SCOPING REVIEW OF ANTIMICROBIAL ACTIVITY AND CLINICAL APPLICATIONS

NANOPARTÍCULAS DE PRATA NA ODONTOLOGIA: UMA REVISÃO DE ESCOPO SOBRE A ATIVIDADE ANTIMICROBIANA E APLICAÇÕES CLÍNICAS

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ABSTRACT: Silver nanoparticles (AgNPs) have gained significant attention in dentistry due to their potent antimicrobial properties. This scoping review aimed to assess the antimicrobial activity of AgNPs and their applications across different dental specialties. The study followed the Joanna Briggs Institute (JBI) methodology. A total of 43 studies met the inclusion criteria and were categorized based on their focus areas. The findings indicate that AgNPs exhibit strong antimicrobial activity against oral pathogens such as *Streptococcus mutans* and *Enterococcus faecalis*, with applications ranging from orthodontic adhesives and root canal disinfectants to coatings for dental implants and prostheses. The review highlights that AgNPs can prevent microbial colonization, reduce biofilm formation, and serve as an alternative to traditional antimicrobial agents, potentially mitigating antibiotic resistance. However, concerns regarding their cytotoxicity and long-term biocompatibility persist. Further in vivo research is needed to validate their efficacy and safety in clinical settings. Future studies should focus on optimizing AgNP concentrations and assessing potential side effects. This review provides an overview of the current evidence on AgNPs in dentistry and emphasizes the importance of further research for their safe and effective clinical application.

Keywords: Antimicrobial activity. Dentistry. Silver nanoparticles.

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RESUMO: As nanopartículas de prata (AgNPs) têm ganhado atenção significativa na odontologia devido às suas potentes propriedades antimicrobianas. Esta revisão de escopo teve como objetivo avaliar a atividade antimicrobiana das AgNPs e suas aplicações em diferentes especialidades odontológicas. O estudo seguiu a metodologia do Joanna Briggs Institute (JBI). Um total de 43 estudos atendeu aos critérios de inclusão e foi categorizado conforme suas áreas de foco. Os resultados indicam que as AgNPs apresentam forte atividade antimicrobiana contra patógenos orais, como *Streptococcus mutans* e *Enterococcus faecalis*, com aplicações que vão desde adesivos ortodônticos e desinfetantes de canais radiculares até revestimentos para implantes dentários e próteses. A revisão destaca que as AgNPs podem prevenir a colonização microbiana, reduzir a formação de biofilme e atuar como alternativa aos agentes antimicrobianos tradicionais, potencialmente mitigando a resistência aos antibióticos. Contudo, persistem preocupações quanto à citotoxicidade e à biocompatibilidade a longo prazo. Mais pesquisas in vivo são necessárias para validar sua eficácia e segurança clínica. Estudos futuros devem focar na otimização das concentrações de AgNPs e na avaliação de possíveis efeitos colaterais. Esta revisão oferece uma visão geral das evidências atuais sobre AgNPs na odontologia e enfatiza a importância de novas pesquisas para sua aplicação clínica segura e eficaz.

Palavras-chave: Atividade antimicrobiana. Odontologia. Nanopartículas de prata.

1. INTRODUCTION

Nanotechnology can be defined as the science that operates on a nanometric, atomic, and molecular scale, working with various types of materials. This versatility allows for the development of distinct properties tailored to specific applications[1]. This technology offers multiple possibilities in fields such as chemistry, physics, engineering, computer science, medicine, and dentistry. Its evident interdisciplinarity and broad range of applications provide significant societal benefits[2].

Among nanomaterials, metallic nanoparticles stand out due to their unique and inherent characteristics. They are widely used across different fields because of their broad spectrum of applications, including antimicrobial, antifungal, antioxidant, antitumor, antiviral, and antiparasitic properties[3].

In nanoparticle synthesis, two main approaches are highlighted: the “top-down” method, which involves breaking down a material to obtain nanometric products, and the “bottom-up” method, in which atoms of elements aggregate to form the desired nanoparticle. These approaches rely on chemical, physical, and biological methods, with the latter being the most commonly used due to its economic and ecological advantages. The biodiversity of accessible biological systems that can serve as mediators in the synthesis process makes it a particularly attractive option[4,5].

In dentistry, among metallic nanoparticles, silver nanoparticles (AgNPs) have been increasingly applied in endodontics[6], implantology[7], periodontics[8], and orthodontics[9],[10] due to their potent antimicrobial action[11]. AgNPs possess strong antibacterial properties, allowing for better biofilm infiltration and exhibiting a lower tendency to induce microbial resistance compared to antibiotics[12].

One of the main challenges in dentistry is the effective elimination of microorganisms from the root canal system. The complex anatomy of these canals can favor bacterial colonization in areas inaccessible to conventional mechanical and chemical endodontic treatments[6]. Due to their nanoscale dimensions, AgNPs have the potential to penetrate previously unreachable areas, enhancing the effectiveness of endodontic treatments[13].

The incorporation of AgNPs into resin-based composites can be advantageous in dental restoration treatments. This integration can help prevent bacterial activity from compromising restorations and reducing their longevity[14]. Additionally, AgNPs can contribute to the prevention of bacterial infections, which are multifactorial microbial inflammatory conditions affecting periodontal tissues[8]. AgNPs can also be integrated into materials such as orthodontic brackets, helping to prevent enamel demineralization and gingivitis during orthodontic treatment[10].

The antibacterial activity of AgNPs appears to be associated with morphological and structural alterations in bacterial cells due to their shape, ultra-small size, and increased surface area. These characteristics facilitate penetration through the bacterial membrane, causing intracellular damage. Several studies suggest that the antibacterial activity of AgNPs is mediated by the formation of reactive oxygen species, which induce modifications in protein and nucleic acid structures, as well as alterations in cell wall permeability, ultimately leading to bacterial cell destruction[15],[16].

This scoping review aimed to highlight the versatility of AgNPs in various fields of dentistry and their recognized antimicrobial effects in dental treatments. The study sought to identify and map key publications to uncover potential knowledge gaps.

2. Material and methods

The study was conducted following the methodology proposed by the Joanna Briggs Institute (JBI), which outlines six methodological steps for conducting a literature review:

formulating the research question, identifying relevant studies, screening studies, extracting data, analyzing data, and presenting results[17].

The research question guiding this study was: What applications related to the antimicrobial activity of AgNPs are reported in the dental literature? The study adhered to the PCC framework: Population – silver nanoparticles; Concept – antimicrobial activity; Context – dentistry.

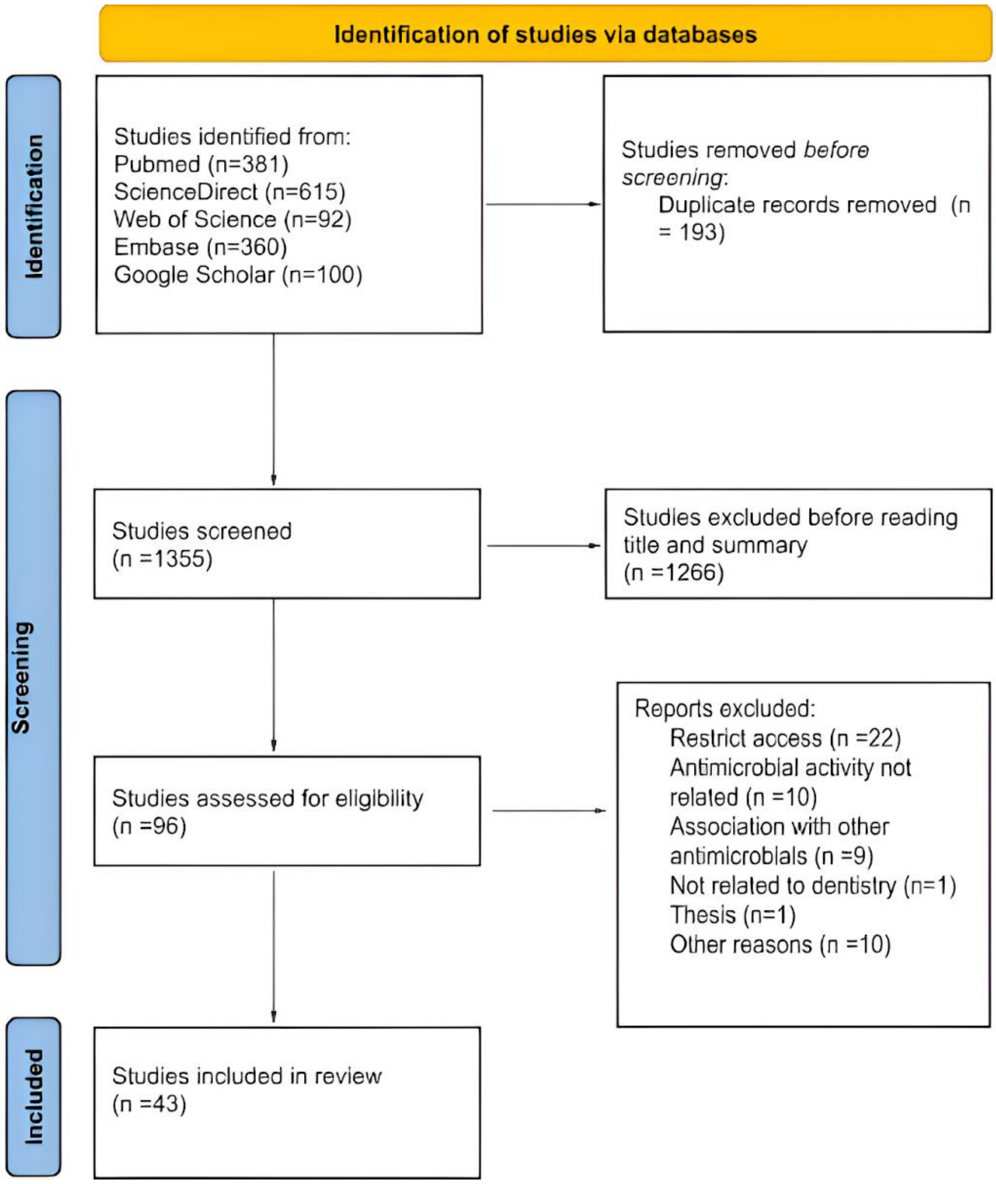
Primary and secondary studies investigating the antimicrobial activity of AgNPs and their applications in dentistry were included. Publications that combined silver nanoparticles with other antimicrobial compounds, as well as in-press articles, editorial letters, reflective studies, and experience reports, were excluded. Electronic searches were conducted between October 2023 and April 2024 across multiple databases, including PubMed, ScienceDirect, Web of Science, and Embase, without restrictions on publication date or language. Additionally, Google Scholar was used to retrieve gray literature.

The search strategy was developed using a combination of descriptors and search terms, integrated with the Boolean operators "AND" and "OR", in accordance with platform-specific search recommendations. In ScienceDirect, filters for "Medicine and Dentistry" and "Open Access & Open Archive" were applied to refine the search results. This research was duly registered on the Open Science Framework (OSF) platform and is accessible via the following DOI: 10.17605/OSF.IO/T96W5.

3. RESULTS

The study selection flowchart is presented in Figure 1. A total of 43 articles met the eligibility criteria and were fully reviewed for data extraction. The results were imported into the software Rayyan for duplicate removal and article selection. Two independent researchers evaluated the titles and abstracts based on the inclusion criteria. Their results were compared to identify any discrepancies in their assessments. Disagreements regarding study inclusion were resolved by consensus, and in cases of persistent disagreement, a third reviewer acted as an arbitrator.

Fig. 1 Flowchart of the selection of publications, according to PRISMA Extension for Scoping Reviews (PRISMAScR)[18].



Source: Prepared by the authors (2025).

The data from in vitro studies assessing the antimicrobial activity of AgNPs associated with dental materials are summarized in Table I. Studies that evaluated the antimicrobial activity of nanoparticles in dentistry without associating AgNPs with dental materials are presented in Table II. Regarding the study design of the selected articles, the review included one systematic review, one in vivo study, and 41 in vitro studies.

Table 1. Characteristics of included in vitro studies that associated AgNPs with dental materials.

Author(reference)	Objectives	Tested Material	Results	Area of Dentistry
1[19]	Evaluate the antimicrobial properties of AgNPs associated with resin-modified glass ionomer.	Glass Ionomer Cement	The incorporation of AgNPs improved the antimicrobial properties of the glass ionomer cement.	Restorative Dentistry
2[20]	Develop a formulation of AgNPs associated with glass ionomer cement and evaluate its antimicrobial activity.	Glass Ionomer Cement	Antimicrobial activity was observed in the glass ionomer cement associated with AgNPs.	Restorative Dentistry
3[21]	Analyze the antimicrobial effect, cytotoxicity, and microtensile bond strength of an adhesive system containing AgNPs.	Adhesive System	Antimicrobial activity was observed in the adhesive system containing AgNPs without altering bond strength or cytotoxicity.	Restorative Dentistry
4[22]	Evaluate the antimicrobial effect of glass ionomer cement incorporated with AgNPs synthesized from mint leaves.	Glass Ionomer Cement	The glass ionomer cement incorporated with AgNPs synthesized using mint leaves showed promising antibacterial effects against cariogenic oral pathogens.	Restorative Dentistry
5[23]	Investigate the effect of AgNPs on the bond strength of dentin from modified adhesives and their antibacterial activities against Streptococcus mutans.	Adhesive System	AgNPs incorporated into the adhesive exhibited antibacterial activities without compromising bond strength.	Restorative Dentistry

6[24]	Evaluate the effect of AgNPs on the bond strength to dentin and their antimicrobial activity against Streptococcus mutans.	Adhesive System	Adhesive systems associated with AgNPs showed superior antimicrobial activity compared to adhesives without AgNPs.	Restorative Dentistry
7[25]	Evaluate the antibacterial properties of a composite resin containing AgNPs.	Composite Resin	The incorporation of AgNPs showed effects in preventing secondary caries.	Restorative Dentistry
8[26]	Assess the efficacy of orthodontic cement containing AgNPs.	Orthodontic Cement	The orthodontic cement with AgNPs demonstrated potential in preventing white spot lesions.	Orthodontics
9[27]	Evaluate the incorporation of AgNPs into orthodontic wires.	Orthodontic Wires	AgNPs proved to be a potential antimicrobial agent for controlling and preventing caries during orthodontic treatments.	Orthodontics
10[28]	Incorporate AgNPs into orthodontic adhesive and evaluate their physicochemical and antimicrobial properties.	Orthodontic Adhesive	The incorporation of AgNP solutions into the adhesive inhibited the growth of Streptococcus mutans.	Orthodontics
11[29]	Analyze the AgNPs produced from the extract of the plant Hetheroteca inuloides, focusing on their antibacterial activity and mechanical properties.	Orthodontic Elastomeric Modules	Orthodontic elastic modules coated with AgNPs can inhibit the growth of significant microorganisms and reduce enamel demineralization.	Orthodontics

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12[30]	Analyze the application of AgNPs in orthodontic adhesives.	Orthodontic Adhesives	AgNPs did not alter the mechanical properties of orthodontic adhesives and exhibited significant antimicrobial effects.	Orthodontics
13[31]	Investigate whether silver-coated orthodontic materials help control infections, prevent plaque formation, and mitigate other associated health risks.	Orthodontic Bands	A potential antimicrobial effect of AgNPs was observed, which could be utilized in orthodontic treatment to prevent dental caries and periodontal infections.	Orthodontics
14[32]	Evaluate the antimicrobial potential of AgNPs associated with acrylic resins used in orthodontics.	Orthodontic Acrylic Resin	AgNPs showed potential to minimize the colonization of cariogenic bacteria and biofilm formation on orthodontic appliances.	Orthodontics
15[33]	Analyze the antibacterial action and the chemical-biological properties of orthodontic wires coated with silver nanoparticles.	Orthodontic Wires	AgNPs demonstrated antibacterial effects by preventing bacterial adhesion and biofilm formation.	Orthodontics
16[34]	Evaluate the antimicrobial efficacy of composite resins containing AgNPs used in fixed orthodontic retainers.	Composite Resin	The incorporation of AgNPs in composite resins exhibited significant antibacterial effects.	Orthodontics

17[35]	Assess the antimicrobial efficacy of AgNPs associated with stainless steel band materials used in orthodontic appliances.	Stainless Steel Bands	The coating of AgNPs on orthodontic bands demonstrated adequate antimicrobial activity during orthodontic treatment.	Orthodontics
18[36]	Evaluate the antimicrobial activity of an orthodontic adhesive containing AgNPs.	Orthodontic Adhesive	Significant antimicrobial activity against Streptococcus mutans was observed.	Orthodontics
19[37]	Evaluate the antimicrobial activity of titanium mini-implants coated with AgNPs.	Titanium Mini-Implants	Titanium mini-implants coated with polymer and AgNPs exhibited excellent antibacterial properties.	Orthodontics
20[13]	Utilize a formulation of AgNPs produced by green synthesis as an intracanal dressing and evaluate its antimicrobial activity.	Intracanal Dressing	The results showed that AgNPs exhibited significant antimicrobial activity.	Endodontics
21[38]	Evaluate the antibacterial effect of a gel preparation containing AgNPs against Enterococcus faecalis present in the root canal walls.	AgNP Gel	The gel exhibited antimicrobial effects against Enterococcus faecalis at both concentrations used, with activity equivalent to that of calcium hydroxide.	Endodontics
22[39]	Evaluate the antibacterial efficacy of AgNPs as an irrigant against Enterococcus faecalis biofilms.	Endodontic Irrigant	AgNPs as a medicament demonstrated potential to eliminate residual bacterial biofilms during root canal disinfection.	Endodontics

23[40]	Determine the antibacterial effect of a colloidal intracanal solution with AgNPs.	Intracanal Colloidal Solution	The solution proved effective against gram-positive bacteria and fungi of the Candida genus.	Endodontics
24[41]	Observe the antibacterial activity of AgNPs.	Endodontic Solution	AgNPs exhibited antimicrobial activity against Enterococcus faecalis.	Endodontics
25[42]	Test the antimicrobial effect of root canal cement after the addition of AgNPs.	Filling Cement	The antimicrobial activity of the root canal cement significantly increased after the addition of AgNPs.	Endodontics
26[43]	Evaluate the effect of a collagen membrane containing AgNPs.	Collagen Membrane	Collagen membranes with 2% AgNPs demonstrated antibacterial capacity and excellent cytocompatibility.	Periodontology
27[44]	Assess the cytotoxicity and antibacterial properties of incorporating AgNPs into the surface coating of dental alloys.	Metal Alloys	AgNPs demonstrated the ability to reduce the cytotoxicity of dental metal alloys but did not show significant antimicrobial activity at different concentrations used, being 10 µmol/L, 4 µml/L, or 2 µmol/L.	Implantology

28[7]	Evaluate the addition of AgNPs to porous titanium surfaces and their antimicrobial activity.	Titanium Implants	Porous titanium surfaces modified and coated with AgNPs demonstrated preferable antibacterial properties compared to pure titanium surfaces.	Implantology
29[45]	Determine the biocompatibility and antifungal properties of facial silicone prostheses coated with AgNPs.	Silicone Maxillofacial Prosthesis	Silicone elastomers coated with AgNPs exhibited antifungal activity.	Prosthetics
30[46]	Evaluate the physical and antifungal characteristics of AgNPs in acrylic base for total prosthesis.	Acrylic Base	The acrylic base for the prosthesis associated with AgNPs exhibited antifungal properties.	Prosthetics

Source: Prepared by the authors (2025).

Table 2. Characteristics of *in vitro* studies included that associated AgNPs with dental materials.

Author(reference)	Objectives	Tested Microorganism	Result	Area of Dentistry
1[8]	Analyze the antimicrobial activity of AgNPs against oral biofilms related to periodontal disease	*Porphyromonas gingivalis*, *Tannerella forsythia*, *Treponema denticola*, *Prevotella intermedia*, *Fusobacterium nucleatum*, and *Aggregatibacter actinomycetemcomitans*	AgNPs exhibited significant inhibitory effects on oral biofilms from patients with and without periodontal disease.	Periodontics

2[47]	Evaluate the antimicrobial activity of AgNPs against oral pathogenic bacteria and their cytotoxicity against human gingival fibroblasts	anaerobic bacteria, Gram-positive and Gram-negative	AgNPs showed antimicrobial potential and low cytotoxic effects.	Periodontics
3[48]	Assess the antibacterial efficacy of AgNPs against *Porphyromonas gingivalis*	*Porphyromonas gingivalis*	AgNPs derived from endophytic fungi demonstrated antimicrobial potential against *Porphyromonas gingivalis*.	Periodontics
4[49]	Test the antimicrobial activity of AgNPs against oral pathogens causing diseases such as caries and periodontal disease	*Aggregatibacter actinomycetemcomitans*, *Fusobacterium nucleatum*, *Streptococcus mitis*, *Streptococcus mutans*, and *Streptococcus sanguinis*	AgNPs showed potential for application in inhibiting oral infections caused by microorganisms, with aerobic bacteria being the most susceptible.	Periodontics
5[50]	Evaluate the antimicrobial properties of biosynthesized AgNPs against cariogenic microorganisms	*Streptococcus mutans* and *Lactobacillus acidophilus*	AgNPs exhibited antimicrobial activity against cariogenic microorganisms.	Caries Research

6[51]	Investigate the biocidal properties of AgNPs against cariogenic bacteria	*Streptococcus mutans, Streptococcus salivarius, Streptococcus sanguinis,* and *Streptococcus mitis*	AgNPs showed potential in the prevention and treatment of caries.	Caries Research
7[52]	Observe the antimicrobial effect of AgNPs synthesized from star anise against *Streptococcus mutans*	*Streptococcus mutans*	AgNPs demonstrated antimicrobial potential and the ability to prevent caries.	Caries Research
8[53]	Determine the antimicrobial effect of AgNPs on different oral biofilms from patients with and without motor and intellectual disabilities	*Streptococcus mutans, Streptococcus sobrinus, Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, Prevotella intermedia, Fusobacterium nucleatum,* and *Aggregatibacter actinomycetemcomitans*	AgNPs exhibited inhibition of bacterial growth against all oral biofilms associated with the patients.	General Dentistry
9[54]	Evaluate AgNPs derived from wild ginger extracts to assess antibacterial efficacy against oral pathogens	*Multidrug-resistant Staphylococcus aureus, Streptococcus mutans,* and *Enterococcus faecalis*	It was found that AgNPs generated from wild ginger extract possess antibacterial activities.	General Dentistry
10[55]	Test the antimicrobial properties of AgNPs obtained through green synthesis mediated by rice extracts	*Staphylococcus aureus, Escherichia coli, Streptococcus mutans,* and *Candida albicans*	The obtained AgNPs exhibited antimicrobial effects.	General Dentistry

11[56]	Determine the antibacterial efficacy of AgNPs synthesized by fungi against pathogens	*Porphyromonas gingivalis, Bacillus pumilus,* and *Enterococcus faecalis*	AgNPs demonstrated antibacterial efficacy against *Porphyromonas gingivalis, Bacillus pumilus,* and *Enterococcus faecalis.*	General Dentistry

Source: Prepared by the authors (2025).

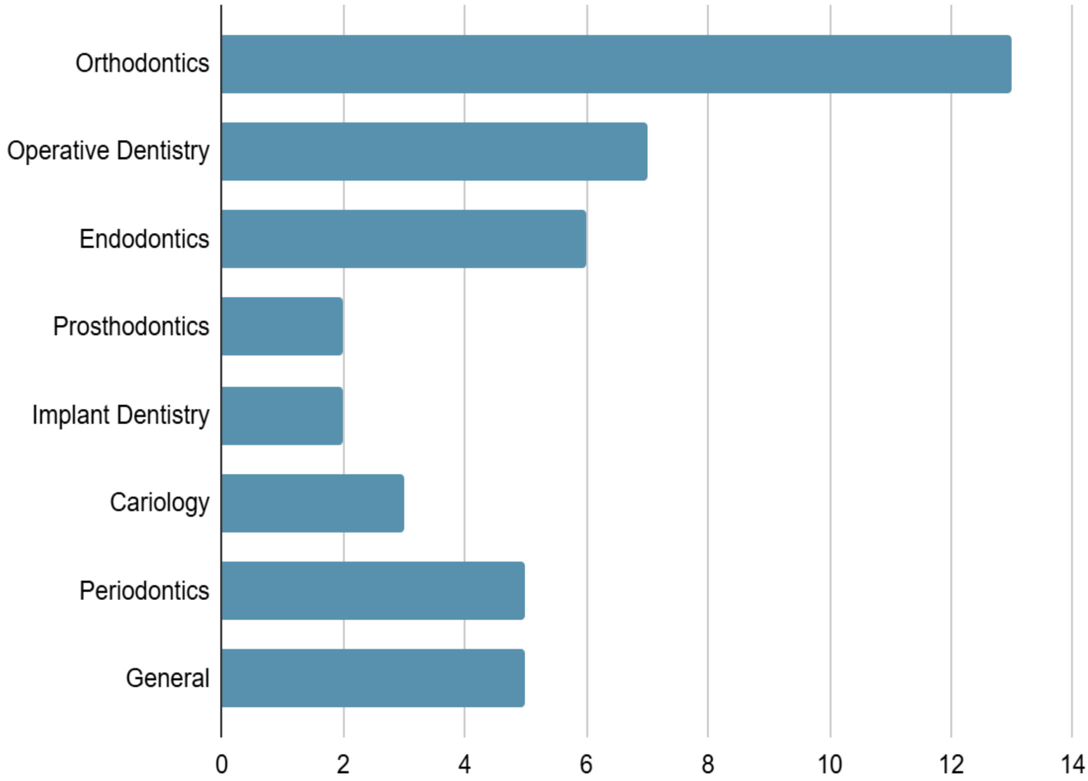
The systematic review included in this study[57] investigated the antimicrobial potential of AgNPs against *Candida albicans*. This review analyzed 18 articles, comprising one randomized clinical trial and 17 in vitro studies. The clinical trial evaluated the effect of acrylic resins containing AgNPs in 30 dental prostheses, divided into three groups: 10 controls, 10 treated with 0.05% AgNPs, and 10 treated with 0.2% AgNPs. The results demonstrated that AgNPs exhibited antimicrobial effects without significantly altering the material's properties, with the 0.2% AgNP group showing the greatest effect against *Candida albicans*.

Among the studies reviewed, only the in vitro study by Nam, Lee, and Lee (2012)[46] was included in both the systematic review by Adam and Klan (2022)[57] and this scoping review. This study, detailed in Table I, and other in vitro investigations indicated that AgNPs incorporated into acrylic prostheses inhibited *Candida albicans* in a dose-dependent manner—as the AgNP concentration increased, fungal growth was progressively reduced.

Additionally, this review included an in vivo laboratory study, which assessed the antimicrobial efficacy of AgNPs in orthodontic adhesives using 28 rodents. The adhesives containing AgNPs were applied to the central incisors of the rats, and the microbial concentration in their saliva was analyzed. The results demonstrated that the antimicrobial effect of AgNPs was dose-dependent, with a minimum concentration of 5% required to ensure efficacy against *Streptococcus mutans, Streptococcus sanguinis,* and *Lactobacillus acidophilus*[58].

Regarding the dental specialties in which AgNPs have been studied for their antimicrobial activity, orthodontics was the most represented, accounting for 30.2% of the included studies. Other specialties were distributed as follows: general dentistry (16.2%), endodontics (14.0%), periodontics (11.6%), cariology (7.0%), prosthodontics (4.7%), and implantology (4.7%). Additionally, 11.6% of the included studies addressed dentistry without specifying a particular specialty (Figure 2).

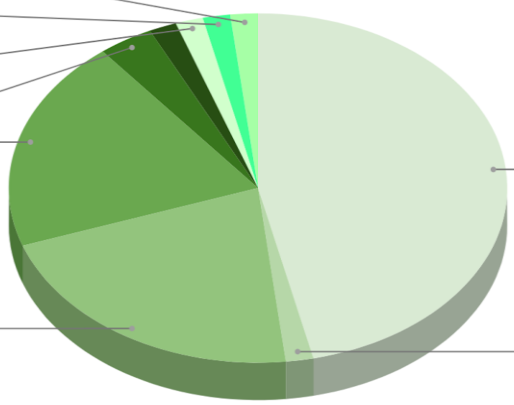
Fig. 2 Overview of the main areas of dentistry conducting studies on AgNPs.



Source: Prepared by the authors (2025).

Regarding the antimicrobial testing methods employed in studies on AgNPs (Figure 3), the agar diffusion method and the colony counting method were the most commonly used. Agar diffusion method is related to an antimicrobial substance is added to a solid culture medium, and the resulting inhibition zone size is measured to determine the minimum inhibitory concentration (MIC)[59]. Colony counting method is a technique to quantifies viable microorganisms in a sample to assess microbial load and evaluate the efficacy of the antimicrobial agent[26].

Fig. 3 Antimicrobial Tests of AgNPs.



Source: Prepared by the authors, 2025.

4. Discussion

Mechanism of Action

Silver nanoparticles (AgNPs) are recognized as potent antimicrobial agents capable of acting against a broad spectrum of microorganisms, including *Streptococcus mutans*[36], *Enterococcus faecalis*[37], and other oral pathogens[22,49]. One of the primary mechanisms by which AgNPs exert their antimicrobial activity is through the continuous release of silver ions, which can disrupt bacterial DNA replication, impair protein function, and compromise the integrity of microbial cell membranes[60]. These properties make AgNPs highly valuable in dentistry, where they have been extensively explored as an additive to enhance the antimicrobial performance of various dental materials across multiple specialties[44].

Clinical Applications

In orthodontics, the incorporation of AgNPs into orthodontic cements has demonstrated significant efficacy in preventing white spot lesions, a common consequence of plaque accumulation due to the difficulty of cleaning around fixed orthodontic appliances[26]. White spot lesions, characterized by enamel demineralization, pose a major aesthetic and structural concern in orthodontic treatment, and AgNPs have been shown to mitigate their formation. Additionally, Bahador et al. (2020)[58] observed in rodent models that the antimicrobial action of AgNPs embedded in orthodontic adhesives is dose-dependent, with a minimum concentration of 5% AgNPs required to effectively inhibit *Streptococcus mutans, Streptococcus sanguinis*, and *Lactobacillus acidophilus*. This dose-dependent response underscores the importance of optimizing nanoparticle concentration to balance antimicrobial efficacy with biocompatibility.

In restorative dentistry, composite resins enhanced with AgNPs exhibit strong antimicrobial properties, helping to prevent secondary caries and bacterial infiltration at the margins of restorations. However, one of the challenges associated with incorporating silver into restorative compounds is its potential to alter the aesthetic quality of restorations due to the possibility of imparting a grayish tint[21]. Conversely, Wang et al. (2022)[23] reported that the incorporation of AgNPs into self-etch adhesives provides excellent antimicrobial activity without compromising essential physical properties, such as bond strength and mechanical integrity.

In periodontics, *in vitro* studies have demonstrated that AgNPs exert antimicrobial effects against periodontal pathogens, reducing bacterial loads in biofilms associated with periodontitis[8]. Hernandez-Venegas et al. (2023) observed that AgNPs had positive effects on both patients with periodontal disease and healthy individuals, indicating promising clinical applications. Additionally, Lu et al. (2013)[49] analyzed AgNPs of different sizes (5, 15, and 55 nm) and concluded that smaller nanoparticles exhibit greater antimicrobial activity, as they facilitate the release of Ag^+ ions, with particles ranging between 1 and 10 nm being the most effective[15],[17].

In implant dentistry, peri-implantitis represents one of the main causes of dental implant failure, triggered by bacterial infections around the implant surface[7]. Modifying implant surfaces with AgNPs has been proposed as an alternative approach to minimize these complications by reducing bacterial adhesion and biofilm formation. However, Shen et al. (2017)[44] reported contradictory results, indicating that the incorporation of AgNPs into dental metal alloys did not result in significant antimicrobial activity. This discrepancy may be attributed to the insufficient concentration of AgNPs (10, 4, and 2 μmol/L) or inadequate preparation methods, highlighting the need for standardization in formulations to ensure antimicrobial efficacy while preserving osseointegration.

In endodontics, AgNPs have been investigated as a potential adjunct in root canal disinfection, particularly against *Enterococcus faecalis*, a bacterium frequently associated with endodontic treatment failures[41]. Their nanoscale size enables penetration into areas inaccessible to conventional irrigants[42,38]. Studies comparing AgNPs with 2% chlorhexidine, one of the most widely used endodontic irrigants, suggest that AgNPs may serve as a viable alternative with comparable or superior antimicrobial effects[6].

In cariology, AgNPs have also been explored for combating *Streptococcus mutans*, the primary etiological agent of dental caries. *In vitro* studies indicate that AgNPs can be incorporated into glass ionomer cement, a widely used restorative material, demonstrating potential to halt caries progression and prevent oral biofilm formation on treated surfaces[20,39].

In prosthetic rehabilitation, the use of dental prostheses is frequently associated with microbial and fungal infections, such as prosthetic stomatitis[46,57]. To mitigate these risks, AgNPs can be incorporated into acrylic bases and resins used for the fabrication and coating of prostheses, conferring antimicrobial and antifungal properties to these materials.

Study Methodology

Methodologically, most of the studies analyzed on the antimicrobial activity of AgNPs in dentistry were based on *in vitro* assays[61]. These studies allow for the controlled evaluation of antimicrobial efficacy and nanoparticle biocompatibility while reducing the need for animal testing. However, *in vitro* studies have inherent limitations, as they do not fully replicate the complexity of physiological systems, which may compromise the extrapolation of results to clinical applications[62].

To overcome these limitations, *in vivo* assays have been conducted using animal models to investigate the efficacy and toxicity of AgNPs in biological systems. These studies are essential for understanding nanoparticle biodistribution and potential adverse effects. Nevertheless, translating *in vitro* findings to *in vivo* contexts remains a challenge, requiring ongoing research to ensure the safety and clinical viability of AgNPs[63].

Safety and Toxicity

A critical aspect related to the use of AgNPs is cytotoxicity, which may result from specific or non-specific interactions with host cells[44]. While some studies have not identified significant cytotoxic effects of AgNPs on human cells[34,38], *in vivo* investigations have reported cytotoxicity in animal models subjected to oral exposure[41]. Thus, further studies are required to determine safe concentrations and assess the long-term impacts of AgNP exposure[44].

Future Perspectives

This study identified silver nanoparticles as an innovative and effective alternative to reducing the indiscriminate use of antibiotics and preventing the selection of multidrug-resistant bacterial strains[54]. Additionally, the research mapped the main areas of dentistry exploring the use of AgNPs, highlighting their potential to optimize dental treatments.

Among the strengths of this study is the comprehensive literature review, conducted using five databases, ensuring a broad survey of AgNP applications in dentistry. Another significant aspect was the identification of gaps in the literature, such as the lack of studies on the effects of AgNPs in living organisms and the scarcity of research on their toxicity. Regarding limitations, although every effort was made to minimize bias, the search strategy may not have captured all relevant studies. Despite this, the findings reinforce the need for more *in vivo* research to fully elucidate the efficacy, safety, and clinical applicability of AgNPs in modern dentistry[64].

5. CONCLUSION

Research on silver nanoparticles (AgNPs) has demonstrated promising effects against pathogens in various fields of dentistry. However, gaps in knowledge remain, particularly regarding their application in living organisms, which require further investigation. Therefore, primary in vivo studies are essential to assess the efficacy and safety of AgNPs as therapeutic options for dental infections, as their potential cytotoxicity to human cells remains an issue that requires further clarification.

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