



## Nano silver in endodontics: A systematic review

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### Abstract

**Background:** Persistent microbial infection is a primary cause of endodontic failure, and novel antimicrobial strategies are being explored to enhance root canal disinfection. Among these, silver nanoparticles (AgNPs) have shown promise due to their unique physicochemical properties and broad-spectrum antimicrobial activity.

**Objective:** To assess the current evidence on the effectiveness of nano silver (AgNPs) when used as an irrigant or intracanal medicament in endodontic therapy.

**Methods:** A systematic search of PubMed, Ovid, and Cochrane Library databases was conducted using the Mesh terms "Nano silver," "AGNPs," "Dental," "Dentistry," "Endodontics," and "Root canal therapy." Studies included in *in vitro*, *in vivo*, and *ex vivo* models assessing AgNPs alone or in combination with other agents. Selection was guided by predefined PICOS criteria. Of 242 records identified, 26 full-text articles were assessed, with 24 studies included in the synthesis. A PRISMA flow diagram illustrates the selection process.

**Results:** AgNPs demonstrated greater antimicrobial efficacy when used as an intracanal medicament compared to an irrigant. Most studies focused on *in vitro* evaluations against *E. faecalis* biofilms. Several formulations, including gels, core-shell particles, and combinations with lasers or CHX, enhanced efficacy. Cytotoxicity assays indicated that AgNPs are generally less toxic than conventional irrigants like sodium hypochlorite and chlorhexidine.

**Conclusion:** Nano silver exhibits significant antimicrobial potential in endodontic disinfection, particularly as an intracanal medicament. While current evidence is promising, clinical studies are necessary to validate *in vitro* findings.

**Keywords:** Silver nanoparticles, nano silver, endodontic irrigant, intracanal medicament, *E. faecalis*, cytotoxicity

### Introduction

Effective disinfection of the root canal system is crucial for the success of endodontic treatment. (1,2). The failure of such therapy is often attributed to the persistence of resistant microorganisms such as *Enterococcus faecalis* and *Candida albicans*. (3,4). Conventional irrigants like sodium hypochlorite (NaOCl) and chlorhexidine (CHX) are widely used, but limitations in biofilm penetration and cytotoxicity have prompted the search for alternatives. Silver nanoparticles (AgNPs), owing to their nanoscale size and enhanced surface reactivity, have emerged as a potential solution for microbial control in endodontics.

This review aims to systematically evaluate the antimicrobial efficacy, biofilm disruption potential, and cytocompatibility of AgNPs when used in root canal therapy.

### Materials and Methods

#### Search Strategy

An electronic literature search was performed across PubMed, Ovid, and the Cochrane Library, using the MeSH terms: "Nano silver (or) AGNPs" and "Dental (or) Dentistry (or) Endodontics (or) Root canal therapy." Additional sources such as OpenGrey and hand-searched references

were also reviewed. The search included articles published in English up to March 2019.

### Eligibility Criteria

#### Inclusion

- *In vitro*, *in vivo*, and *ex vivo* studies
- Use of nano silver in any form (solution, gel, composite)
- Evaluation against endodontic microflora

#### Exclusion

- Non-endodontic pathogens
- Nano silver in caries or periodontal applications
- Non-nano silver forms

### PICOS Framework

**Population:** Human and animal models of root canal infection

**Intervention:** Nano silver as irrigant, medicament, or sealer

**Comparison:** Conventional materials (e.g., NaOCl, CHX)

**Outcome:** Reduction of bacterial load, biofilm disruption

**Study Design:** Experimental (*in vitro*, *ex vivo*, *in vivo*)

(See Table 1 for detailed PICOS structure)

**Table 1:** MeSH terms and PICOS format considered for the review

PICOS	Population	Intervention	Comparison	Outcome
Characteristics considered	Humans/animals	Nano silver (in any form, alone or in combination with other materials)	Conventional endodontic materials	Efficacy in bacterial load reduction and efficacy in biofilm disruption.
MeSH terms	Nano silver (or) AGNP's and Dental (or)Dentistry (or) Endodontics (or) Root canal therapy			

**Study Selection and Data Extraction**

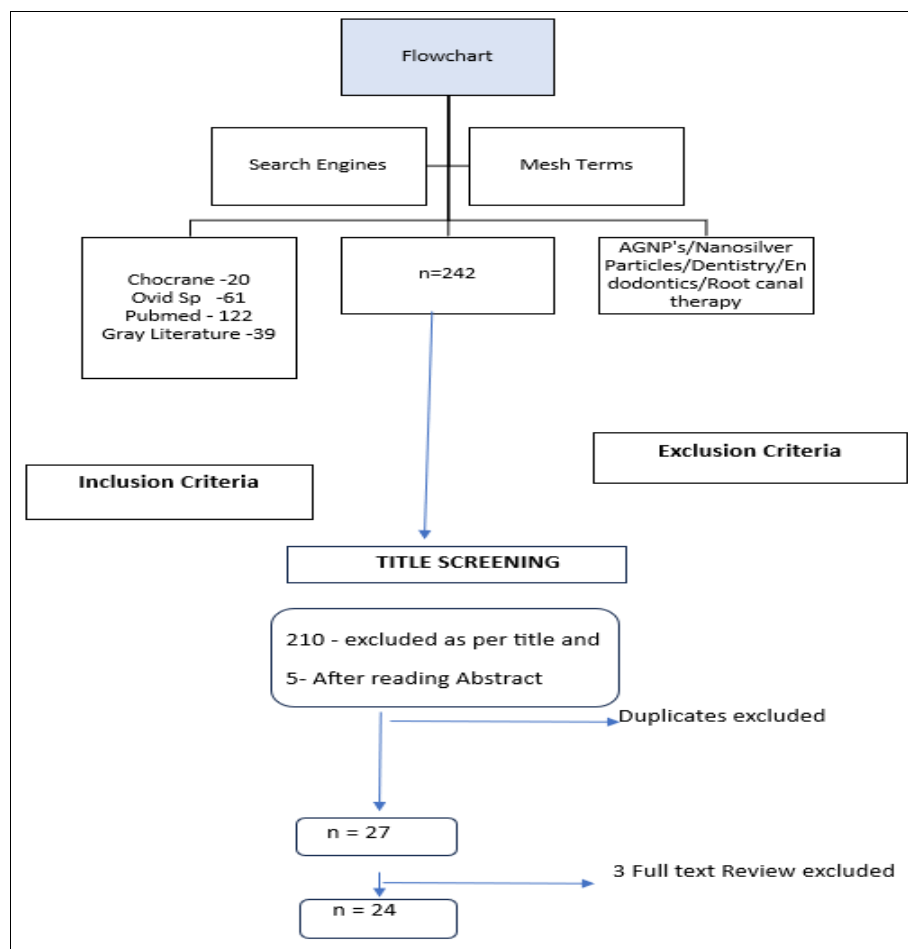
A total of 242 articles were retrieved, of which 26 were eligible for full-text review. Three articles were excluded due to lack of relevance to endodontic pathogens (5-7), (Table 2). Ultimately, 24 studies were included in qualitative synthesis. (8-28), (Except for review articles) [27-29]

**Types of study:** All the studies are in-vitro studies [8, 26] (Except for review articles) [27, 29]

*In vitro* studies done on Human extracted teeth Wu 2014, [25] Abbaszadegan 2015 [17], Afkhami 2015 [22], Chan 2015 [23], Abbaszadegan 2017 [17], Afkhami 2017 [20], Ertem 2017 [18], Yavari 2017 [21], Charannya 2018 [8], de Almeida 2018 [9], Kushwaha 2018 [12], Moazami 2018 [13], Samiei 2018 [11], Seung 2018 [15], Zheng 2018 [16], Sadek 2019 [10]. *In vitro studies done on Bovine teeth* Rodrigues 2018 [14], *Rats* Gomes-Filho 2010, Zand 2016 [26, 30]. **Cytotoxic studies** Gomes-Filho 2010, Abbaszadegan 2015, Afkhami 2015, Chan 2015, Abbaszadegan 2017, Ertem 2017, Zheng 2018 [16-18, 22-24, 26].

**Table 2:** Articles Excluded with reasons

S. no.	Excluded article	Reasons	Ref
1.	Panpaliya NP, Dahake PT, Kale YJ, Dadpe MV, Kendre SB, Siddiqi AG, Maggavi UR. In vitro evaluation of antimicrobial property of silver nanoparticles and chlorhexidine against five different oral pathogenic bacteria. Saudi Dent J. 2019 Jan;31(1):76-83.	Endodontic pathogens were not tested.	
2.	Misba L, Kulshrestha S, Khan AU. Antibiofilm action of a toluidine blue O-silver nanoparticle conjugate on Streptococcus mutans: a mechanism of type I photodynamic therapy. Biofouling. 2016;32(3):313-28.	Endodontic pathogens were not tested.	
3.	Besinis A, De Peralta T, Handy RD. Inhibition of biofilm formation and antibacterial properties of a silver nano-coating on human dentine. Nanotoxicology. 2014 Nov;8(7):745-54.	Endodontic pathogens were not tested.	



**Fig 1:** The study selection process is illustrated in the PRISMA flowchart

## Results

### Characteristics of Included Studies

Many studies were in *in vitro*, with a focus on *E. faecalis* biofilms. Forms of AgNPs tested included intact particles, coated variants, gels, and composites. Studies varied in

concentration (1 ppm to 100 ppm), size (5–30 nm), and application protocols (2-minute irrigation to 7-day medicament exposure).

(Refer to Table 3 for included studies)

**Table-3:** Articles included for full text review:

S. no	Details of included articles	Source
1.	Charannya S, Duraivel D, Padminee K, Poorni S, Nishanthine C, Srinivasan MR. Comparative Evaluation of Antimicrobial Efficacy of Silver Nanoparticles and 2% Chlorhexidine Gluconate When Used Alone and in Combination Assessed Using Agar Diffusion Method: An In vitro Study. <i>Contemp Clin Dent</i> . 2018 Sep;9(Suppl 2):S204-S209.	Pubmed
2.	De Almeida J, Cechella BC, Bernardi AV, de Lima Pimenta A, Felipe WT. Effectiveness of nanoparticles solutions and conventional endodontic irrigants against <i>Enterococcus faecalis</i> biofilm. <i>Indian J Dent Res</i> . 2018 May-Jun;29(3):347-351.	Pubmed
3.	Sadek RW, Moussa SM, El Backly RM, Hammouda AF. Evaluation of the Efficacy of Three Antimicrobial Agents Used for Regenerative Endodontics: An In Vitro Study. <i>Microb Drug Resist</i> . 2019 Jan 11.	Pubmed
4.	Kushwaha V, Yadav RK, Tikku AP, Chandra A, Verma P, Gupta P, Shakya VK. Comparative evaluation of antibacterial effect of nanoparticles and lasers against Endodontic Microbiota: An in vitro study. <i>J Clin Exp Dent</i> . 2018;10(12):e1155-60.	Pubmed
5.	Moazami F, Sahebi S, Ahzan S. Tooth Discoloration Induced by Imidazolium Based Silver Nanoparticles as an Intracanal Irrigant. <i>J Dent (Shiraz)</i> . 2018 Dec;19(4):280-286.	Pubmed
6.	Rodrigues CT, de Andrade FB, de Vasconcelos LRSM, Midena RZ, Pereira TC, Kuga MC, Duarte MAH, Bernardineli N. Antibacterial properties of silver nanoparticles as a root canal irrigant against <i>Enterococcus faecalis</i> biofilm and infected dentinal tubules. <i>Int Endod J</i> . 2018 Aug;51(8):901-911.	Pubmed, OvidSP
7.	Samiei M, Torab A, Hosseini O, Abbasi T, Abdollahi AA, Divband B. Antibacterial Effect of Two Nano Zinc Oxide Gel Preparations Compared to Calcium Hydroxide and Chlorhexidine Mixture. <i>Iran Endod J</i> . 2018 Summer;13(3):305-311.	Pubmed
8.	Seung J, Weir MD, Melo MAS, Romberg E, Nosrat A, Xu HHK, Tordik PA. A Modified Resin Sealer: Physical and Antibacterial Properties. <i>J Endod</i> . 2018 Oct;44(10):1553-1557.	Pubmed, OvidSP
9.	Zheng T, Huang X, Chen J, Feng D, Mei L, Huang Y, Quan G, Zhu C, Singh V, Ran H, Pan X, Wu CY, Wu C. A liquid crystalline precursor incorporating chlorhexidine acetate and silver nanoparticles for root canal disinfection. <i>Biomater Sci</i> . 2018 Feb 27;6(3):596-603.	Pubmed
10.	Abbaszadegan A, Gholami A, Abbaszadegan S, Aleyasin ZS, Ghahramani Y, Dorostkar S, Hemmateenejad B, Ghasemi Y, Sharghi H. The Effects of Different Ionic Liquid Coatings and the Length of Alkyl Chain on Antimicrobial and Cytotoxic Properties of Silver Nanoparticles. <i>Iran Endod J</i> . 2017 Fall;12(4):481-487.	Pubmed
11.	Ertem E, Gutt B, Zuber F, Allegri S, Le Ouay B, Mefti S, Formentin K, Stellacci F, Ren Q. Core-Shell Silver Nanoparticles in Endodontic Disinfection Solutions Enable Long-Term Antimicrobial Effect on Oral Biofilms. <i>ACS Appl Mater Interfaces</i> . 2017 Oct 11;9(40):34762-34772.	Pubmed
12.	Yavari H, Ghasemi N, Divband B, Rezaei Y, Jabbari G, Payahoo S. The effect of photodynamic therapy and polymer solution containing nano-particles of Ag/ZnO on push-out bond strength of the sealers AH-Plus and MTA Fillapex. <i>J Clin Exp Dent</i> . 2017 Sep 1;9(9):e1109-e1114.	Pubmed
13.	Afkhami F, Akbari S, Chiniforush N. <i>Enterococcus faecalis</i> Elimination in Root Canals Using Silver Nanoparticles, Photodynamic Therapy, Diode Laser, or Laser-activated Nanoparticles: An In Vitro Study. <i>J Endod</i> . 2017 Feb;43(2):279-	Pubmed, OvidSP

	282.	
14.	Afkhami F, Pourhashemi SJ, Sadegh M, Salehi Y, Fard MJ. Antibiofilm efficacy of silver nanoparticles as a vehicle for calcium hydroxide medicament against <i>Enterococcus faecalis</i> . <i>J Dent</i> . 2015 Dec;43(12):1573-9.	Pubmed
15.	Chan EL, Zhang C, Cheung GS. Cytotoxicity of a novel nano-silver particle endodontic irrigant. <i>Clin Cosmet Investig Dent</i> . 2015 Jul 13;7:65-74.	Pubmed
16.	Samiei M, Ghasemi N, Divband B, Balaei E, Hosien Soroush Barhaghi M, Divband A. Antibacterial efficacy of polymer containing nanoparticles in comparison with sodium hypochlorite in infected root canals. <i>Minerva Stomatol</i> . 2015 Dec;64(6):275-81.	Pubmed
17.	Zand V, Lotfi M, Aghbali A, Mesgariabbasi M, Janani M, Mokhtari H, Tehranchi P, Pakdel SM. Tissue Reaction and Biocompatibility of Implanted Mineral Trioxide Aggregate with Silver Nanoparticles in a Rat Model. <i>Iran Endod J</i> . 2016 Winter;11(1):13-6.	Pubmed
18.	Abbaszadegan A, Nabavizadeh M, Gholami A, Aleyasin ZS, Dorostkar S, Saliminasab M, Ghasemi Y, Hemmateenejad B, Sharghi H. Positively charged imidazolium-based ionic liquid-protected silver nanoparticles: a promising disinfectant in root canal treatment. <i>Int Endod J</i> . 2015 Aug;48(8):790-800.	Pubmed
19.	Mozayeni MA, Haeri A, Dianat O, Jafari AR. Antimicrobial effects of four intracanal medicaments on <i>enterococcus faecalis</i> : an in vitro study. <i>Iran Endod J</i> . 2014 Summer;9(3):195-8. Epub 2014 Jul 5.	Pubmed
20.	Wu D, Fan W, Kishen A, Gutmann JL, Fan B. Evaluation of the antibacterial efficacy of silver nanoparticles against <i>Enterococcus faecalis</i> biofilm. <i>J Endod</i> 2014;40:285-90.	Pubmed, OvidSP
21.	Gomes-Filho JE, Silva FO, Watanabe S, Cintra LT, Tendoro KV, Dalto LG, Pacanaro SV, Lodi CS, de Melo FF. Tissue reaction to silver nanoparticles dispersion as an alternative irrigating solution. <i>J Endod</i> . 2010 Oct;36(10):1698-702. doi: 10.1016/j.joen.2010.07.007.	Pubmed
<b>Review articles included for analysis</b>		
22.	Noronha VT, Paula AJ, Durán G, Galembeck A, Cogo-Müller K, Franz-Montan M, Durán N. Silver nanoparticles in dentistry. <i>Dent Mater</i> . 2017 Oct;33(10):1110-1126.	Pubmed
23.	Samiei M, Farjami A, Dizaj SM, Lotfipour F. Nanoparticles for antimicrobial purposes in Endodontics: A systematic review of in vitro studies. <i>Mater Sci Eng C Mater Biol Appl</i> . 2016 Jan 1;58:1269-78.	Pubmed
24.	Shrestha A, Kishen A. Antibacterial Nanoparticles in Endodontics: A Review. <i>J Endod</i> . 2016 Oct;42(10):1417-26.	Pubmed

### Antimicrobial Efficacy

AgNPs demonstrated superior performance as intracanal medicaments, particularly when used in gel forms or combined with calcium hydroxide or laser irradiation. Combination protocols—such as AgNPs with Nd: YAG laser or CHX—enhanced efficacy against mature biofilms.

### Biofilm Disruption

Longer contact duration and higher concentrations of AgNPs were correlated with greater biofilm disruption. Studies reported improved results for AgNPs used as medicaments rather than irrigants, due to prolonged interaction with microbial biofilms.

### Cytotoxicity

Cytotoxicity tests showed that AgNPs are generally less toxic to fibroblasts and periodontal ligament cells than NaOCl or CHX. Modified nanoparticles, such as positively charged imidazolium-coated AgNPs, exhibited lower cytotoxicity and maintained antimicrobial activity.

### Discussion

This review indicates that nano silver exhibits notable antimicrobial and antibiofilm effects in endodontics, with reduced cytotoxicity compared to traditional agents. The efficacy is influenced by multiple factors including concentration, particle size, surface charge, capping agents, and mode of delivery.

Only one study directly compared AgNPs as both irrigant and medicament, revealing higher efficacy in the latter. While these *in vitro* and *ex vivo* findings are promising, translation into clinical practice requires further evidence from human trials.

### Limitations and Future Directions

- Most data are derived from laboratory studies lacking clinical validation.
- Variation in synthesis methods, formulations, and testing protocols limits comparability.
- Further *in vivo* and clinical trials are essential to establish safe and effective clinical protocols for AgNP use.

## Conclusion

Nano silver holds promise as an endodontic antimicrobial agent, particularly when used as an intracanal medicament. Its efficacy can be further enhanced through combination with lasers, CHX, or carrier systems such as lyotropic liquid crystals. Future clinical research is warranted to determine its optimal use and long-term safety.

## Tables and Figures

- Table 1: PICOS Criteria and MeSH Terms
- Table 2: Excluded Studies and Reasons
- Table 3: Included Studies
- Figure 1: PRISMA Flow Diagram

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