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Silver Nanoparticles in Periodontics: A survey to assess Knowledge, Attitude, and Practice among Dental Professionals

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ABSTRACT

Background: Silver nanoparticles have shown promise due to its antibacterial, antifungal, and anti-inflammatory properties, as a topical adjunct in treating periodontitis. Despite its potential, the adoption of silver nanoparticles (AgNPs) in clinical practice is limited. Therefore, a study was done to assess the current awareness and attitudes of dental practitioners towards AgNPs, aiming to inform educational efforts and address barriers, ultimately enhancing periodontal therapy outcomes.

Methods and Results: An online survey of 113 dental practitioners practicing in India revealed that though they are aware of nanotechnology in general, their understanding of the particular uses of silver nanoparticles in periodontics is still limited.

Conclusion: This emphasized the necessity of improved training, more clinical studies, and evidence-based procedures to enable the safe and efficient use of silver nanoparticles into periodontal therapy.

KEY WORDS

Silver nanoparticles, Periodontal therapy, Dental professionals

INTRODUCTION

Periodontitis, ranked as the eleventh most common disease worldwide (Global Burden of Disease Study, 2016) affects 20% - 50% of people globally and is among the main reasons for tooth loss¹. The regular mode of treating periodontitis involves performing non-surgical and surgical procedures along with adjunct antibiotics and mouthwashes to remove the cause.

Systemic antibiotics like amoxicillin, doxycycline, and metronidazole, as well as local antimicrobials like chlorhexidine rinses, sustained-release chips, and tetracycline derivatives administered directly into the periodontal pocket, are common antimicrobial adjuncts used^{2,3}.

Due to antimicrobial resistance, the extensive and frequent usage of antibiotics may still result in recurrent infections, which would reduce their efficacy. To prevent or overcome these drawbacks, there is an urgent requirement of other treatment options.

Silver in the recent past has emerged as a topic of interest as it is seen to show anti-bacterial, anti-fungal, anti-viral, anti-inflammatory properties⁴. This metal has been utilized in humans as silver nitrate or silver sulfadiazine in creams and dressings to treat burns and ulcers, in water filters, in food packaging to prevent contamination⁵. From literature it can be observed that silver can confidently be tried as a topical alternative to antibiotics for the treatment of various diseases including periodontitis. According to various studies silver in its nano form incorporated into acrylic dentures and periodontal dressings has been shown to possess antifungal and antibacterial effects respectively⁶.

Though, nanotechnology, is gaining huge popularity in the field of dentistry due to its multiple properties and benefits, Dentists are still using conventional treatments (like scaling and root planing with established antibiotics). The clinical use of this material is still in its infancy, due to lack of awareness and significant concerns regarding safety and long-term toxicity in humans. The utilization and efficacy of new technology may be predicted by KAP variables, according to the analysis of previous research. For instance, even when new technologies are accessible and beneficial, ignorance prevents them from being used (Bashir et al., 2023).

Therefore, despite growing evidence, the clinical adoption of using silver nanoparticles within the dental community is still limited and varies widely. Understanding the level of knowledge, attitude, and practice patterns (KAP) among dental professionals is essential to identify barriers to the integration of AgNPs into routine periodontal care. The scientific advantages, suitable indications, safety concerns, and legal requirements pertaining to the use of AgNP may be unknown to many practitioners. Others could be misinformed or worried about long-term effects, expense, or cytotoxicity. Assessing these elements is essential since the effective integration of new technology into clinical practice is heavily influenced by practitioner acceptability.

This study was done to determine and know the present knowledge and awareness of dental practitioners and their attitude regarding the use of AgNPs. The results can therefore direct educational initiatives, influence policy choices, encourage the evidence-based use of nanotechnology, and point out areas that require more study or training. Ultimately, by encouraging the safe and efficient use of nanomaterials, silver nanoparticles in particular will help in improving the results of periodontal therapy

In future, silver nanoparticles can become a part of the routine practice. Hence this survey was conducted to clear any doubts and clarifications or fears and concerns present among the dental professionals which hinders them from using this emerging technology. Addressing the existing issues and publishing them provides a valuable, transparent data, which can

guide future research and clinical application of silver nanoparticles (AgNPs) in periodontal therapy.

AIM: The aim of the study was to evaluate the level of knowledge and clinical perceptions among dental professionals concerning the use of silver nanoparticles (AgNPs) as an emerging adjunct in periodontal therapy.

The objectives were:

- 1.To evaluate the awareness of Silver Nanoparticles among dental practitioners.
2. To determine the level of knowledge of the use of Silver Nanoparticles in Periodontal therapy
3. To assess the attitudes toward the use of Silver Nanoparticles in Periodontics.
- 4.To analyze the current practices involving Silver Nanoparticles in Periodontal therapy.

Methodology

A cross- sectional survey was conducted using an online questionnaire (Google Forms) to evaluate the knowledge, attitude, and practice (KAP) of dental practitioners on silver nanoparticles in periodontal therapy. The questionnaires were sent to dental professionals practising in India. The participants were given a period of two weeks to complete the survey.

Using Habeeb et al.'s prevalence = 94.1% ($p = 0.941$) and the standard assumptions for sample-size calculation in prevalence studies (95% confidence level, 5% absolute precision), sample size was calculated using the formula:

$$n = \frac{Z^2 \cdot p \cdot q}{d^2}$$

A sample size of 86 was obtained. 10% of the sample was added to compensate for the sampling loss.

RESULTS:

A total of 113 responses could be obtained. This involved practicing post graduates from all specialties in Dentistry, general practitioners and postgraduate students. Dental students, interns, or non-dental health-care professionals, dental professionals practising outside India and participants who failed to finish important parts of the survey were excluded from the study.

Table 1 Questionnaire with percentage of responses.

SL NO	QUESTION	PERCENTAGE OF THE RESPONSES
1.	Qualification	• BDS 28.3 % • MDS 71.7%
2.	Subject of specialization	• General Practioner 27.4% • Specialist 72.6%
3.	Years of clinical experience	• < 2 years 19.6% • 2-5 years 46.4% • 6-10 years 17.9% • 10 years and more 16.1%
4.	Type of practice	• General practice 38.9% • Specialty practice (Periodontics) 31.9 • Academic/Research institution 20.4% • Hospital setting 8.8%
5.	Gender	• Male 65.5% • Female 34.5% • Other/Prefer not to disclose 0%
6.	Age group	• Under 30- 27.4% • 30-40- 66.4% • 41-50- 5.3% • Over -50 0.9%
7.	Are you aware of the term "nanotechnology" in dentistry? (Fig 1.1)	• Yes 93.8% • No 6.3%
8.	Where did you get information about nanoparticles from? (Fig 1.2)	• Clinical training/Dental school curriculum 48.2% • Scientific journals and publications 51.8% • Conferences and CDE programs 30.4% • Industry representatives/Advertisements 5.4% • Online resources/General media 31.3% • Discussions with colleagues/experts 15.2%

		• Other 1.8%
9.	Nanoparticles are generally defined as materials with a size range of	• < 1 mm 3.6% • < 1 μm 25.9% • < 100 nm 40.2% • < 10 nm 19.6% • Unsure 10.7%
10.	Are you aware of the use of silver nanoparticles (AgNPs) in periodontal therapy? (Fig 1.3)	• Yes 60.2% • No 39.8%
11.	What are the primary properties of silver nanoparticles that make them useful in periodontics? (Select all that apply)	• Antibacterial activity 60.2% • Anti-inflammatory properties 32.7% • Enhanced mechanical strength of materials 17.7% • Improved aesthetics 7.1% • Regenerative potential for periodontal tissues 33.6% • Unsure 26.5%
12.	In which periodontal treatment modalities have AgNPs been studied or applied? (Select all that apply)	• Subgingival drug delivery after scaling and root planing (SRP) 54.5 % • Incorporation into periodontal dressings 29.5 % • Use in implant surfaces 24.1% • As an irrigant solution 10.7 % • In bone regeneration scaffolds 21.4% • Unsure 35.7%
13.	Please share your concern or opinion on the potential safety or cytotoxicity associated with AgNPs? (Fig 2.1)	• No idea • Safe • Not sure • Prolonged ingestion for a long term might cause cytotoxicity • Not aware much • Silver nanoparticles can be used safely within the safety dosage and the safety limits and in the safety size range • long term effects • There is not much cytotoxicity associated with this

14.	Do you believe that specific training or certification should be required for dental professionals to use nanotechnology-based materials?	• Yes 74.3 % • No 10.6% • Unsure 15%
15.	On a scale of 1 to 5, how would you rate the potential of AgNPs to improve periodontal treatment outcomes? (1=Strongly Disagree, 5=Strongly Agree) (Fig 2.2)	• 1 (2.8%) • 2 (9.3%) • 3 (46.7%) • 4 (28%) • 5 (13.1 %)
16.	Do you believe AgNPs offer an advantage over conventional treatment methods (e.g., local antibiotics) for periodontitis?	• Yes, a significant advantage 30.6% • Yes, a slight advantage 33.3% • No, they are comparable 6.5% • No, conventional methods are better 1.9% • Unsure 27.8%
17.	How willing are you to incorporate AgNP-based products into your clinical practice, provided there is sufficient evidence of safety and efficacy? (Fig 2.3)	• Very willing 18.7 % • Willing 43.9% • Neutral 37.4 % • Unwilling • Very unwilling
18.	What is your perception of the current level of research on AgNP safety in periodontics?	• Extensive and sufficient 4.6% • Moderate 45.9 % • Limited and insufficient 25.7 % • Unsure 23.9%
19.	Have you used any AgNP-based materials or products in your clinical practice? (Fig 2.4)	• Yes 20.7% • No 79.3%
20.	If yes, in which specific procedures have you used them? (Select all that apply or describe)	• Periodontal pocket irrigation 8% • As a component of restorative materials 26% • In periodontal dressings 24% • On implant surfaces 18% • Other (specify) 16 %
21.	If no, what are the main reasons preventing you from using AgNP-based materials? (Fig 2.5)	• Lack of awareness/knowledge 55.8 % • Lack of clinical guidelines/protocols 51.6% • Concern about safety and toxicity 25.3% • High cost of materials 17.9%

		• Limited commercial availability of products 26.3% • Lack of confidence in product efficacy 16.8 %
22.	Would you recommend AgNP-based treatments to your patients if they were a viable option?	• Yes, definitely 20% • Yes, with caution 41% • No, I would not 2.9% • Depends on the specific patient case 20%

Knowledge & Awareness

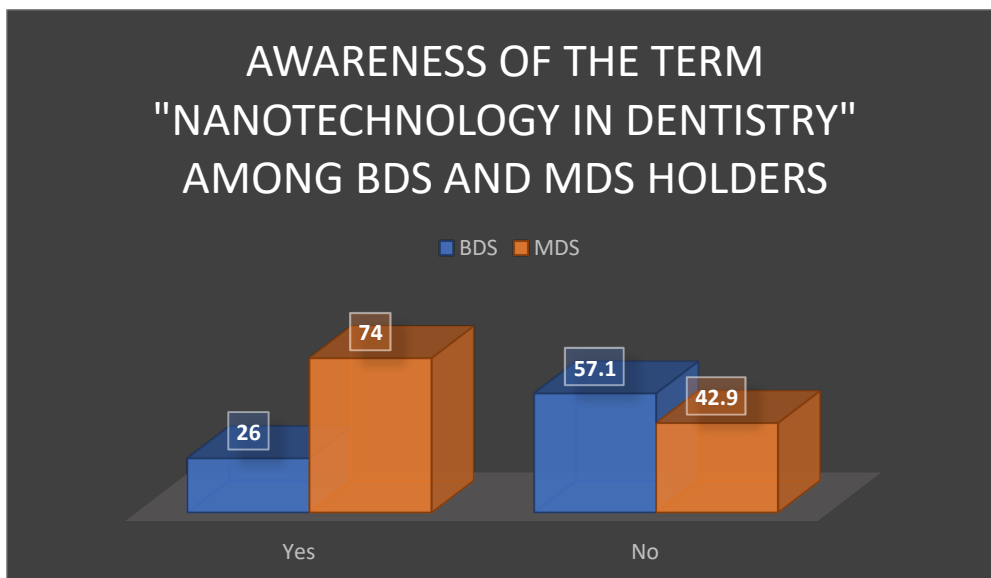


Fig1.1

Awareness of the term "nanotechnology in dentistry" among BDS and MDS holders

(The figure should appear immediately below **“Table 1 Questionnaire with percentage of responses.”**)

It is the figure of the question: “7.Are you aware of the term "nanotechnology" in dentistry?” from Table 1)

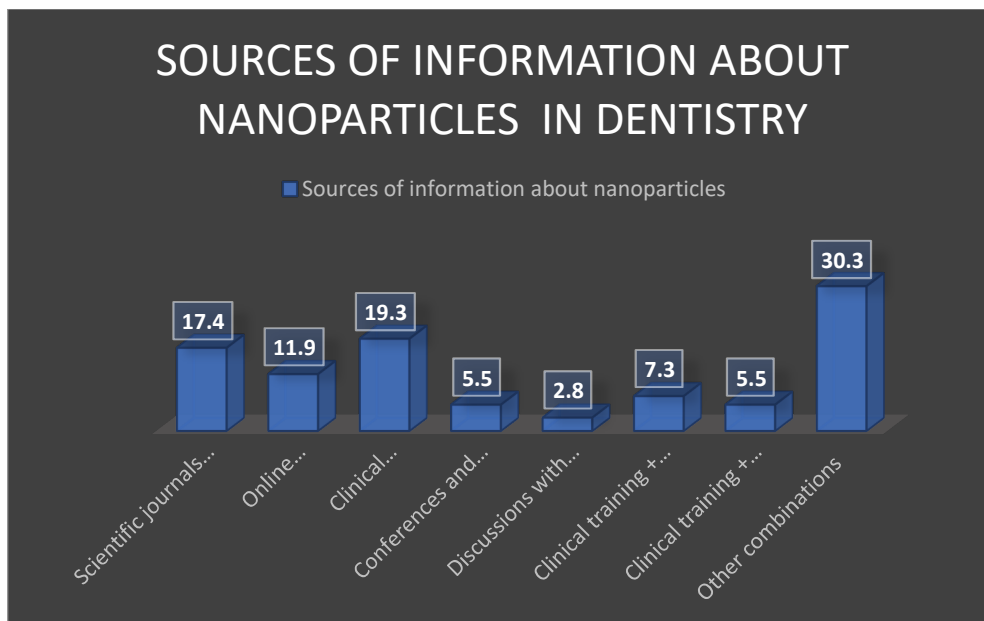


Fig 1.2
Sources of information about nanoparticles

(The figure should appear after Fig 1.1

It is the figure of the question: "8. Where did you get information about nanoparticles from?" from Table 1)

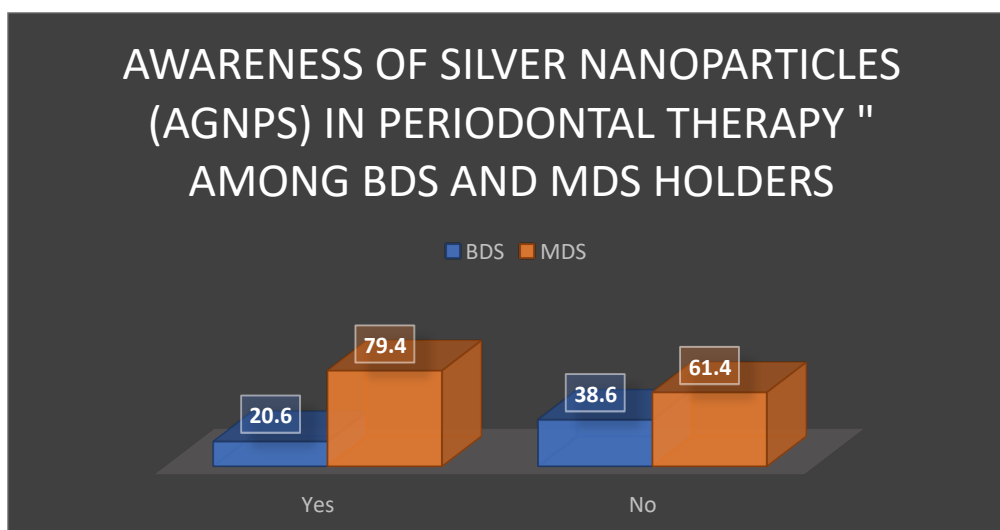


Fig 1.3
Awareness of "silver nanoparticles (AgNPs) in periodontal therapy" among BDS and MDS holders

(The figure should appear after Fig 1.2

It is the figure of the question: "10. Are you aware of the use of silver nanoparticles (AgNPs) in periodontal therapy?" from Table 1)

Clinical Application & Perceptions

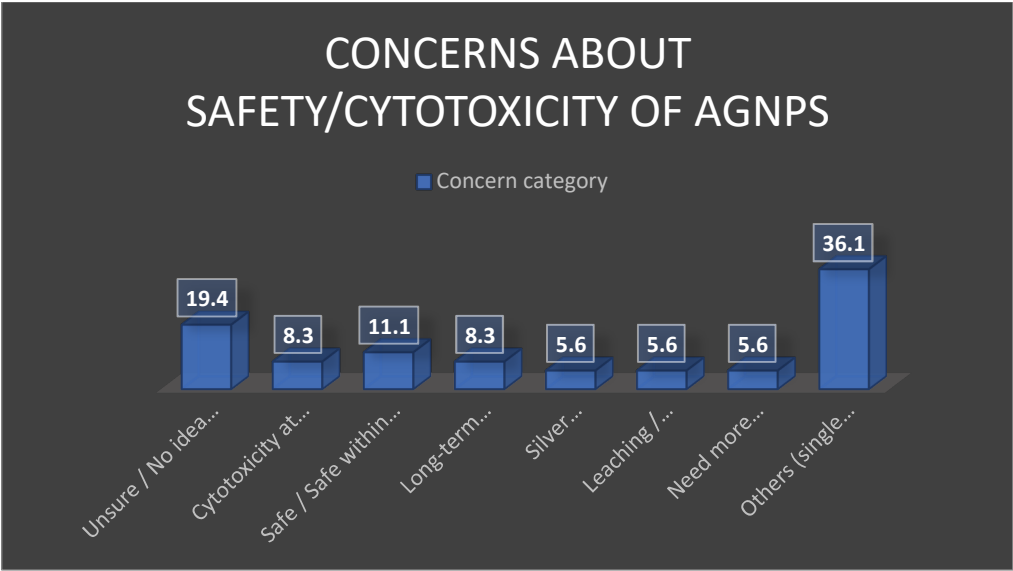


Fig 2.1
Concerns about safety/cytotoxicity of AgNPs

(The figure should appear after Fig 1.3.

It is the figure of the question: “13. Please share your concern or opinion on the potential safety or cytotoxicity associated with AgNPs” from Table 1)

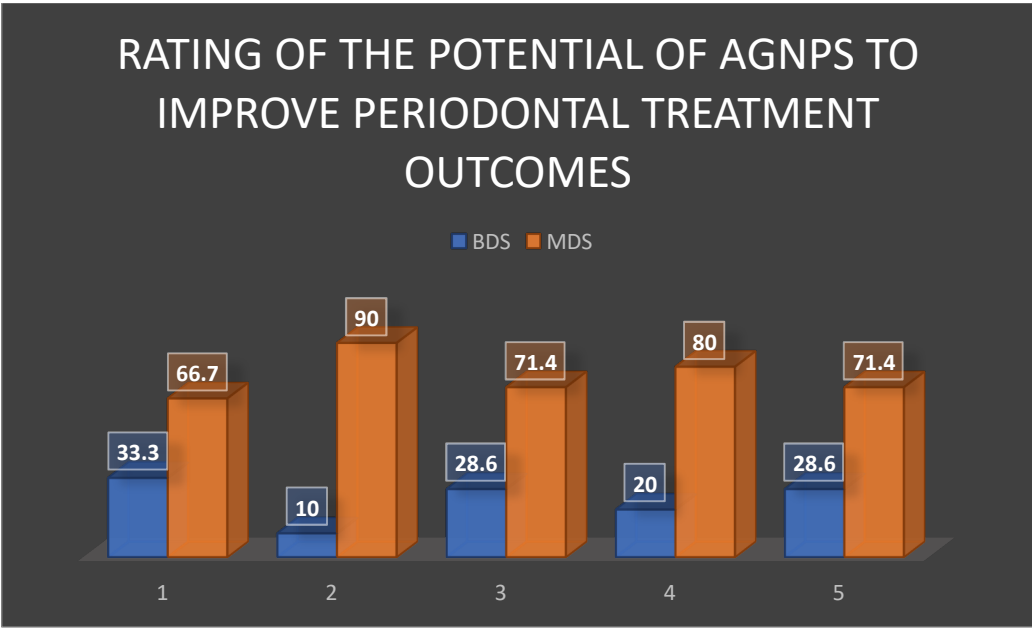


Fig 2.2

Rating of AgNPs' potential to improve periodontal treatment outcomes based on perception

(The figure should appear after Fig 2.1

It is the figure of the question: “15. On a scale of 1 to 5, how would you rate the potential of AgNPs to improve periodontal treatment outcomes?” from Table 1)

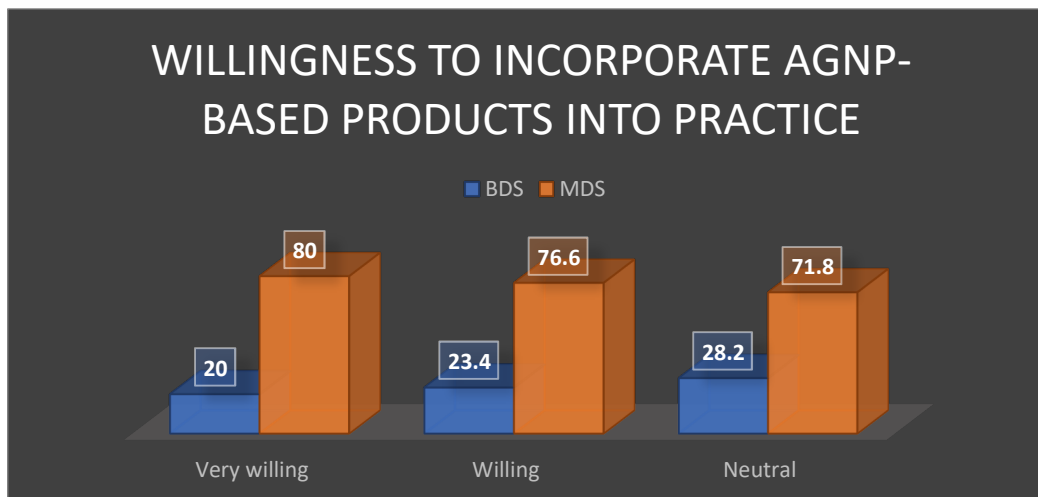


Fig 2.3

Willingness to incorporate AgNP-based products into practice

(The figure should appear after Fig 2.2

It is the figure of the question: “17. How willing are you to incorporate AgNP-based products into your clinical practice, provided there is sufficient evidence of safety and efficacy?” from Table 1)

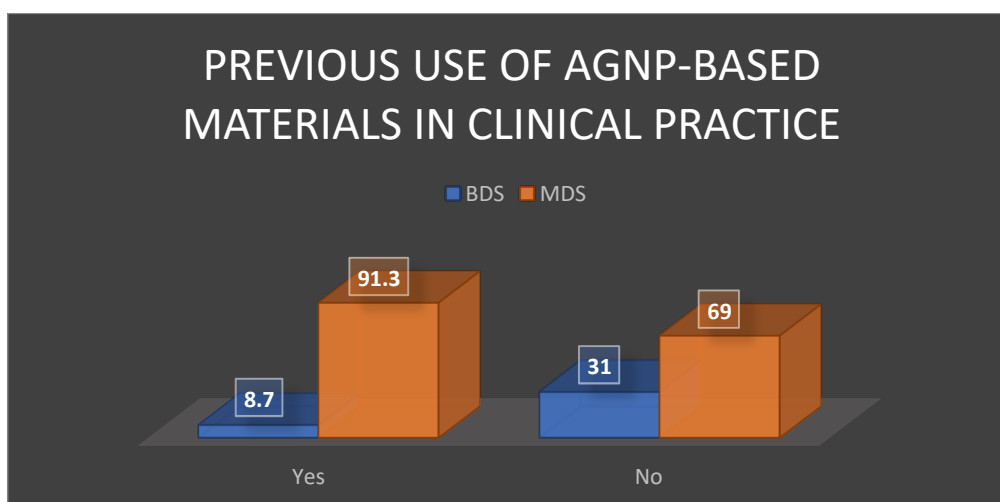


Fig 2.4

Previous use of AgNP-based materials in clinical practice

(The figure should appear after Fig 2.3

It is the figure of the question: “19. Have you used any AgNP-based materials or products in your clinical practice?” from Table 1)

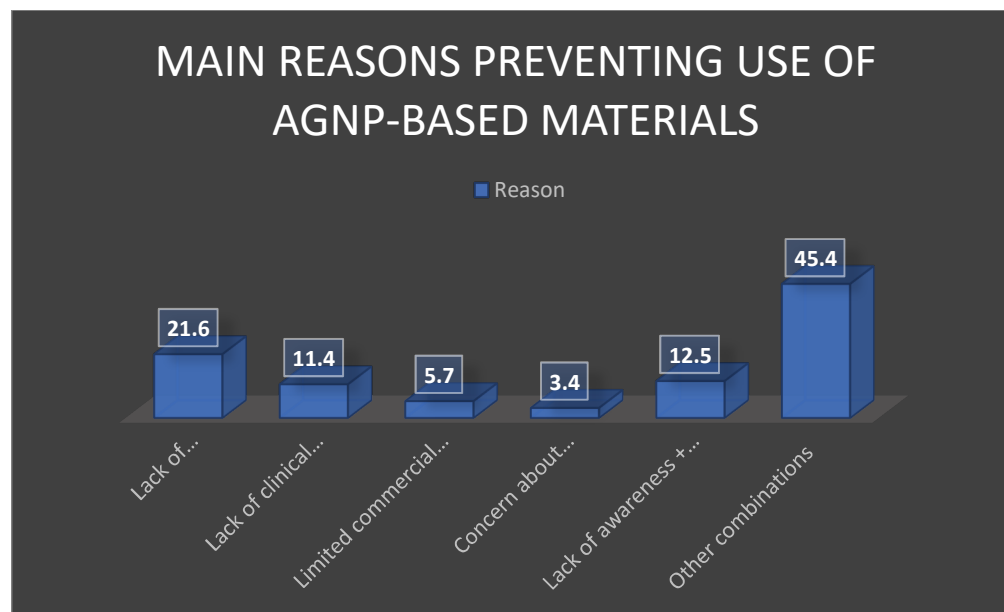


Fig 2.5

Main reasons preventing use of AgNP-based materials

(The figure should appear after Fig 2.4

It is the figure of the question: “21. If no, what are the main reasons preventing you from using AgNP-based materials? ” from Table 1)

DISCUSSION

Periodontitis significantly contributes to the burden of chronic non-communicable diseases.⁶ While adjunctive treatments like antibiotics and local drug delivery agents have limitations, including drug resistance, silver has shown promise due to its antimicrobial and anti-inflammatory properties without the mentioned limitations.^{7,8} Despite the growing use of silver nanoparticles in dentistry, awareness remains low, with concerns about safety and toxicity among dentists. The awareness of its use in periodontal treatment in particular needs to be improved among dental practitioners.

This study was therefore conducted to assess the knowledge, attitude, and practice of dental professionals regarding the use of silver nanoparticles (AgNPs) in periodontics. Among the participants 72.3% were MDS holders, and 27.7% were BDS holders. The BDS holders were working as either general practitioners or in hospital settings. MDS holders were there from

all specialties with periodontists being the maximum as the topic of the survey was more relevant to this speciality.

The awareness of the topic was seen to be maximum among the MDS holders. Among those unaware, BDS holders (57.1%) outnumbered MDS holders (42.9). This suggests a need for higher awareness among the recent graduates regarding the latest and newest modes of treatment available in the market and of those topics/materials under research.

According to the responses the most common single source through which they acquired information/knowledge was clinical training/dental school curriculum which amounted up to 19.3%. This shows that the primary, formal education obtained from dental schools/colleges are the main source of professional knowledge. A large proportion (30.3%) of the responders acquired knowledge through multiple sources, indicating that knowledge is acquired through combined formal education, literature, and peer discussion. Scientific journals (17.4%), online resources (11.9%) were the other resources. Conferences and CDE programs have to be conducted more as these accounted to be the least common resource (5.5%).

When asked about the definition of nanoparticle size range, 40.5% of the participants (45 out of 111) could select the correct definition from among the various options provided. Uncertainty was seen to be higher among BDS holders with 58.3% being unsure. MDS holders were more likely to select <100 nm (77.8%). A significant misconception was noted with 29.7% having selected <1 nm which is too small.

Awareness of its use was significant with 60.7% of the responders being aware of the use of AgNPs in periodontal therapy. Among the MDS holders, 66.7% (54 out of 81) were aware but there was very less awareness among the BDS holders (45.2%) indicating a knowledge gap among general practitioners. There was also a high uncertainty in the knowledge of the properties of AgNPs useful in periodontics as only 8.9% correctly identified the combination of antibacterial, anti-inflammatory, and regenerative potential. When asked regarding the treatment modalities where AgNPs have been studied/applied, there was very high uncertainty. Subgingival drug delivery after SRP alone was the most recognized modality (19.8%). The overall, knowledge of specific clinical applications is limited, with most respondents either unsure or able to identify only one modality.

Awareness on the clinical application & perceptions gave an idea that most of the responders were unsure about the safety. Among those concerned about the safety the concerns listed were cytotoxicity at high concentrations (8.3%), long-term effects being unknown (8.3%), silver accumulation/organ toxicity (5.6%), leaching/staining potential (5.6%). 11.1% of the participants gave positive perceptions where they stated that AgNPs are safe or safe within dosage limits. The need for more research was explicitly mentioned by 5.6%. A wide variety of single responses (36.1%) were obtained like “Silver accumulation in liver causes various health problems. The use of silver nanoparticles causes discoloration of gingiva. Chitosan nanoparticles or copper nanoparticles cause less discoloration and are less harmful when compared to silver”. Some mentioned that “expertise is required and expenses are more if these have to be used”. Some were “doubtful regarding the use of silver nanoparticles in pregnancy”. Other responses included:

- They may cause oxidative stress and membrane disruption,

- Are they bio compatible?,
- The concentration & dosage of AgNPs for different application is not known to most practitioners,
- Precaution should be taken when using AgNP.” These responses indicate a lack of standardized knowledge and diverse personal opinions.

Overwhelming majority (74.1%) of the responders believe training/certification should be required to use silver nano particles on a regular basis, only 10.7% said ‘no’ to the need for training/certification. A cautious optimism was the prevailing attitude when asked about the potential of AgNPs to improve periodontal outcomes but 64.5% believe AgNPs offer at least a slight advantage over conventional methods of treatment. Only 1.9% believe conventional methods are better. 6.5% said they are comparable and 27.1% were unsure, reflecting ongoing uncertainty despite positive leanings. No BDS holder said conventional methods are better; only MDS holders expressed that view (2 respondents).

63.2% of the participants were willing or were very willing to incorporate AgNP products with MDS holders showing a slightly higher positive attitude (20.0% of MDS vs. 15.4% of BDS). 36.8% remained neutral. None of the respondents selected "unwilling" which is a very positive finding.

The overall usage of AgNP was low, with only 20.9% having used AgNP-based materials. The specialists are much more likely to have used them (91.3% of users were MDS) with only 8.7% of BDS holders have had used such materials. This reflected a limited clinical translation and/or lack of availability of the required materials. Among the users, the applications were as a component of restorative materials (19.0%), in periodontal dressings (19.0%), on implant surfaces (11.9%), as periodontal pocket irrigation (4.8%). A large proportion (45.2%) fell into "other/unspecified," suggesting varied or off-label use or lack of standardized terminology. Main reasons preventing use of AgNP-based materials were lack of awareness/knowledge (21.6%), lack of clinical guidelines/protocols (11.4%), limited commercial availability (5.7% alone), concern about safety and toxicity (3.4%), high cost (1.1%). This highlights educational and policy gaps.

CONCLUSION

The present study found that although dental professionals possess high general awareness of nanotechnology, knowledge regarding the specific applications of silver nanoparticles in periodontics remains moderate and fragmented. Specialists demonstrated significantly greater awareness and clinical experience with AgNPs than general practitioners. Despite limited use in routine practice, respondents showed favourable perceptions toward the potential benefits of AgNPs and a strong willingness to adopt AgNP-based products when supported by robust scientific evidence. Lack of knowledge, absence of clinical guidelines, and safety concerns were identified as major barriers to implementation.

These findings highlight the need for enhanced education, further clinical research, and evidence-based protocols to facilitate the safe and effective integration of silver nanoparticles into periodontal practice.

DECLARATIONS

Abbreviations

1. Knowledge, attitude, and practice patterns: KAP
2. Silver nanoparticles: AgNPs
3. Bachelor of Dental Surgery: BDS
4. Master of Dental Surgery: MDS
5. Continuing Dental Education: CDE

Ethics approval: Ethical clearance was obtained from Institutional Ethics Committee

JSSDCH IEC Research Protocol No: 97/2025

(JSSDCH IEC: JSS Dental College & Hospital Institutional Ethics Committee)

Consent to participate: NA

The need for consent to participate was waived by Institutional Ethics Committee

JSSDCH IEC (JSSDCH IEC: JSS Dental College & Hospital Institutional Ethics Committee)

Study was approved by: from Institutional Ethics Committee

JSSDCH IEC Research Protocol No: 97/2025

(JSSDCH IEC: JSS Dental College & Hospital Institutional Ethics Committee)

Consent for publication: NA

Availability of data and materials: The research protocol was prepared from previous research and the data described in this article can be accessed from the reference list

Competing Interests: The authors declare that they have no competing Interests

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Accordance statement:

All methods were carried out in accordance with relevant guidelines and regulations. Experimental protocols were approved by the Institutional Ethics Committee

JSSDCH IEC Research Protocol No: 97/2025

(JSSDCH IEC: JSS Dental College & Hospital Institutional Ethics Committee)

Authors' contributions:

CAM: wrote the main manuscript, prepared tables and figures, conception of the work, acquisition, analysis, interpretation of data, drafted the work

AKG: conception of the work, acquisition, analysis, interpretation of data, drafted the work

BSM: conception of the work, acquisition, analysis, interpretation of data, drafted the work

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