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Knowledge, Attitudes, and Practices Regarding Nanoparticles in Endodontics: A Survey Study

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Abstract

It is now possible to enhance the use of antimicrobial agents in endodontic therapy through the use of nanoparticles, which offers new prospects in dental treatment. However, little is known about the level of sophistication of these dental practitioners regarding their awareness and use of these technologies in practice. Therefore, this study aimed to assess the KAP of dental practitioners on the use of nanoparticles in endodontic therapy. An online self-completed cross-sectional survey was conducted among general practitioners, endodontists, and dental students. The findings indicated that among the overall respondents, 94.1% of participants were aware of nanoparticles and their potential, and only 10.8% had incorporated them into their clinical practice. A total of 91.8% of the respondents had a positive attitude towards the use of nanoparticles in root canal therapy which implies that they found nanoparticles useful. However, the gap between the level of awareness and actual usage points to some of the hurdles such as; the inability to access the materials and poor understanding of how best to apply them. The study also emphasizes the need to increase awareness and availability of nanoparticle-containing products to improve the application of nanoparticles in clinical endodontics due to the identified gap in the translation of research findings into practice.

Keywords: *Nanoparticles, Endodontics, KAP, Dental Practitioners, Antimicrobial, Root Canal Therapy.*

1. Introduction

The nanoparticles are being incorporated in different fields of medicine and dentistry because they come with some other characteristics than the bulk materials. Nanoparticles are particles that are from 1 to 100 nanometers in size; they have large surface area to volume and size-related characteristics which make them suitable for use in various fields (Ijaz et al., 2020). It has been found in the present literature that nanoparticles have the potential to enhance the efficiency of the treatment in endodontics. For example, it was proved that silver nanoparticles can exhibit high antimicrobial activity that may be very useful in eradicating the resistant bacteria in the root canal space (Afkhami et al., 2021). In addition, the slow release of silver ions increases the efficiency of the silver in disinfection and reduces the possibility of recontamination (Thangavelu et al., 2021). The other important application is the use of calcium hydroxide nanoparticles that are being incorporated in cementitious composites. In contrast with the common calcium hydroxide, these nanoparticles are more reactive and have a favorable relationship with the dental tissues resulting in better mineral deposition and regeneration of the dentin (Naseri et al., 2019). Likewise, hydroxyapatite nanoparticles are being used to evaluate their potential in the remineralization of tooth enamel and dentin to enhance the outcomes of the restorative processes (Imran et al.,

2023). Such developments show that the nanoparticles are capable of providing for some of the problems that are characteristic of the conventional material used in the endodontic processes. The use of nanoparticles in endodontic treatments has multiple advantages. It is also much smaller in size and this makes it easier for it to navigate through complex shapes of root canals thus improving on the cleaning and decontamination procedures. The tiny size of nanoparticles makes it possible for it to reach some regions that could otherwise not be reached through other methods thereby improving debridement and reducing the chances of failure (Kolimi et al., 2022). In addition, nanoparticles can be designed to deliver therapeutic agents such as antimicrobials or growth factors for an extended period, and therefore there is a reduced need for applications. This controlled release capability results in a prolonged therapeutic effect in comparison to systemic antibiotics and has a role in the general management of endodontic infections and tissue healing/ regeneration (Makvandi et al., 2021). Recent developments in nanotechnology also enable the production of new materials that possess enhanced mechanical characteristics. One can find ways to introduce the nanoparticles into the endodontic sealers and fillers to improve the mechanical properties and adhesion. This leads to enhanced positioning of the root canal and less possibility of failure of treatment through leakage or debonding (Zakrzewski et al., 2021). These advances reveal that the nanoparticles could probably serve one or many purposes in managing problems in endodontic treatment and the quality of patient's health. The extent to which these new technologies, nanoparticles in this case, can be implemented in clinical practice is a function of the KAP of the dentists. Awareness relates to the extent of knowledge that practitioners possess about the properties and uses of nanoparticles. This includes awareness of new technologies and possible gains that these technologies may contain. They are perceived factors like the level of confidence that the practitioners have in the effectiveness of nanoparticles, perceived risks of nanoparticles, and perceived safety of nanoparticles. They pertain to the application and integration of nanoparticles in clinical settings. From the analysis of the above studies, it can be concluded that KAP factors are predictors of the utilization and effectiveness of new technologies. For example, a lack of knowledge leads to the non-use of new technologies even if they are available and useful (Bashir et al., 2023). This means that a positive attitude on its own may not be sufficient to implement new technologies; a negative attitude or skepticism may slow down implementation. Such factors may assist in the determination of factors that hinder the adoption process and how such factors can be addressed; this may include; organizing sessions to inform the targeted persons and create awareness. For such reasons, it is important to measure the KAP on nanoparticles. First, it helps in identifying the areas of practice within which the practitioners are not fully informed. If a majority of endodontists are not aware of the benefits and relevance of nanoparticles, then the application of nanoparticles makes it quite difficult in clinical practice (Raula et al., 2020). Such gaps should be closed through education and training in the best practices in the use of nanoparticles. Second, assessing the perception towards nanoparticles may assist in establishing whether there are issues or even negative attitudes towards the same among the practitioners. For example, if the practitioners have some concerns about the safety or efficacy of nanoparticles, they will not use them in their practice. Knowledge of these attitudes is helpful in the creation of rational information and the depiction of the applicability of nanoparticles clinically to these attitudes (Hussein et al., 2019). Nevertheless, at the end of current practices, one gets to know the use of nanoparticles in endodontic procedures. This information can be utilized as a starting point and used to develop policies on the use of nanoparticles. It also shows the areas to explore or enhance to increase the usage of nanoparticles in endodontic therapy (Alfirdous et al., 2021). That is, the knowledge, attitude, and practice of nanoparticles in endodontics must be known to prevent the issues that affect the utilization of nanoparticles and promote their use in practice. However, as they remain areas of uncertainty and fear and the principles of use

of nanoparticles are decided upon, the benefits of the nanoparticles can be directed towards the enhancement of the probability of success in endodontic procedures.

2. Objectives of the study

- To test the subject-matter knowledge of the participants regarding nanoparticles and their applications in endodontics.
- To evaluate attitudes toward the use of nanoparticles in endodontics.
- To examine the current practices involving nanoparticles in endodontic procedures.

3. Methodology

3.1 Study Design

In this work, cross-sectional survey research was used to evaluate the knowledge, attitudes, and practices (KAP) of dental practitioners on nanoparticles in endodontic treatment. The rationale for using the survey method was chosen because it is possible to receive the data from a large number of respondents and get an understanding of how the nanoparticles are seen and used in practice by different dental practitioners and students. It also facilitates the collection of data on the participants' knowledge and practice regarding the use of nanoparticles in endodontic treatments.

3.2 Participants

The participants for the study were drawn from a list of dental practitioners in an attempt to have a cross-sectional sample that would give an outlook into the current understanding and practice of endodontics. This involved general practitioners, postgraduate students, practicing endodontists, and undergraduate students. To be able to cover a large population of people and to be able to have people from all over the geographical area and from different groups, an electronic survey was used. Only members who had any experience or knowledge, especially in endodontic treatments were allowed to participate in the study. This means that both practicing dentists, as well as students who are currently learning dentistry, were encouraged to participate. The participants who had no prior knowledge of endodontics or the participants who were not able to complete the survey were excluded from the analysis to ensure that the data collected was valid and reliable. The demographic characteristics of the participants included students and working dental professionals at various stages of their practice. This diversity was beneficial in getting a more or less equal perspective on the knowledge, attitude, and practice as far as the use of nanoparticles in endodontics is concerned. The participants were not chosen by their age and years of working experience in the dental field and this made the sample to be general in capturing the subject matter.

3.3 Survey Instrument

The questions in the survey instrument were derived from prior studies and discussions with the experts to ensure that the questions were suitable for the use of nanoparticles in endodontics. The questionnaire was structured into three main sections knowledge, attitudes, and practices. The knowledge section focused on the participants' understanding of nanoparticles and the antibacterial properties of nanoparticles particularly silver nanoparticles in endodontic practice. The attitudes section established the perceived applicability and openness for using nanoparticle-based treatments in clinical practice while the practices section determined the frequency and approach towards the use of nanoparticle-based irrigants during procedures. To ensure the validity of the questionnaire, the pilot test was conducted on five dental professionals to test the simplicity and clarity of the questionnaire items. The internal consistency of the survey was determined by using Cronbach's alpha coefficient for the reliability of the survey while the content and face validity of the questionnaires were

determined by the subject experts to ensure the questions posed were relevant to the study objectives and suitable for the targeted sample population.

3.4 Data Collection

The data collection technique used in the study was an online survey whereby the participants were allowed to fill out the survey at their own volition. The questions given in the survey were in the form of multiple choice questions and Likert scale questions regarding knowledge, attitude, and practice (KAP) about the use of nanoparticles in endodontics. The survey was done online and the participants were given two weeks to complete the survey, though they were reminded to ensure that they responded in adequate numbers. The whole data collection process was for four weeks so that all the participants could fill up the survey and the research team could reach them if required.

3.5 Data Analysis

The statistical analysis of the data was done with the help of Statistical Package for Social Science version (SPSS) 20.0 to enable the analysis of survey data that will be obtained from the participants. To report the demographic profile of the participants, basic frequency and percentage were used. The chi-square tests were employed to analyze the relationship between demographic factors and participants' KAP about nanoparticles. Knowledge, Attitudes, and Practices data were analyzed by placing them in categories about the frequencies of the responses obtained. The chi-square test also extended the comparison of the participants' use of the nanoparticle-based irrigants and their knowledge and perception of the materials. A 95% confidence interval was applied, and a p-value of <0.05 was considered statistically significant.

4. Results

4.1 Demographics of Participants

The survey was conducted with 389 participants, with the majority hailing from India (64.0%). Other countries represented were Pakistan (1.3%), the USA (0.5%), and a few other areas which showed a very diverse geographical distribution. In terms of professional background, undergraduate students formed the largest group (32.6%), followed closely by post-graduate students (28.5%) and practicing endodontists (23.4%). A smaller part included general practitioners with 14.1% of the total number of respondents. The participants were mostly within the age of 20-30 years representing 73.5 per cent of the respondents, further implying that the sample comprised mainly young persons, especially in their early working years. This demographic distribution shows that most of the dental personnel are young and inexperienced and this is evidenced by the fact that most of the respondents were either in school or had just left school.

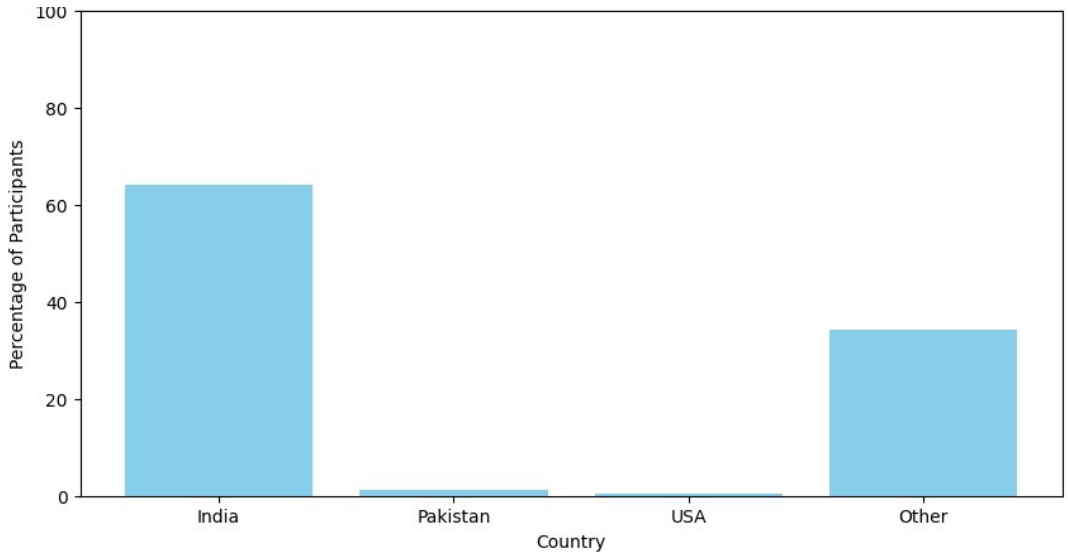

Fig 1: Geographical Distribution of Survey Participants.

4.2 Knowledge Regarding Nanoparticles

From the survey conducted, the respondents had a good level of awareness of nanoparticles with 94.1% having heard of the term. Additionally, 69.2% of the participants said they had a prior understanding of the overall bactericidal nature of silver nanoparticles, especially in eradicating bacterial films in endodontic procedures. However, there was a notable gap in practical knowledge, as only 29.3% of respondents were aware that silver nanoparticles could be synthesized in an eco-friendly manner using plant extracts. This implies that although there is a wealth of information on nanoparticles and their uses, there might be little knowledge on the green synthesis of nanoparticles and the use of nanoparticles in clinical practice.

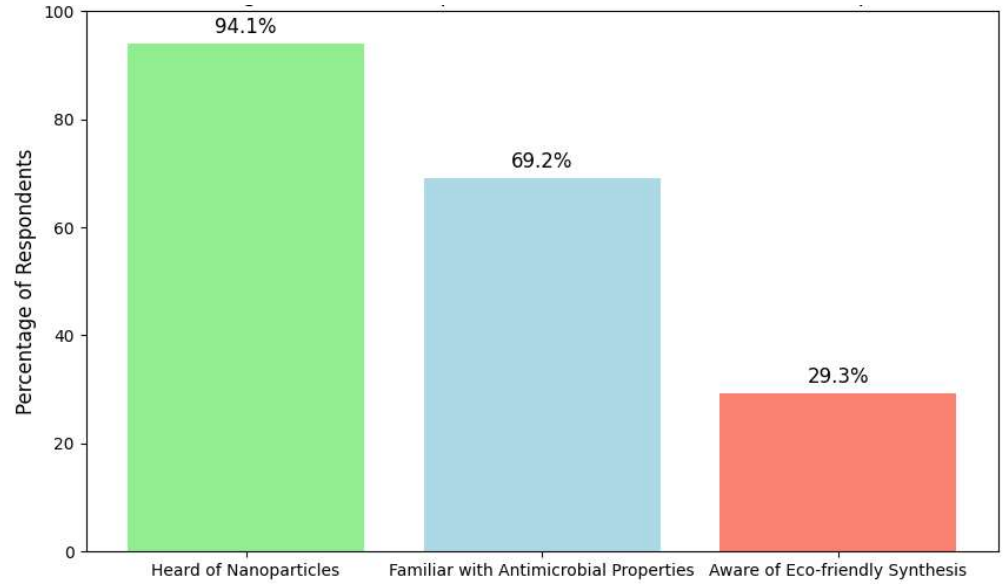

Fig 2: Knowledge of Silver Nanoparticles and Their Antimicrobial Properties.

4.3 Attitudes Towards Nanoparticles

Regarding the attitudes, the majority of the participants (91.8%) considered the use of nanoparticles crucial in the treatment of root canals. This shows appreciation for their efforts to improve the treatment of their patients and acknowledges their capacity in the treatment processes. Additionally, 65.8% of respondents were aware of the use of silver nanoparticles as a root canal irrigant, reflecting a generally positive perception of their application in clinical settings. The overall attitude means that the majority of participants are willing to introduce nanoparticle-based solutions into practice in case they have appropriate tools and information.

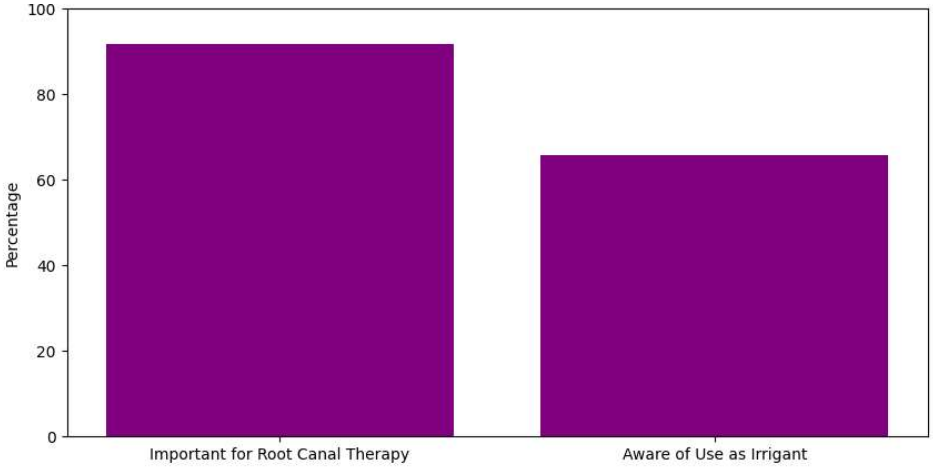

Fig 3: Attitudes Towards the Importance of Nanoparticles in Root Canal Therapy.

4.4 Practices Involving Nanoparticles

However, the results of the present study showed that even having a high level of awareness and understanding of the application of nanoparticle-based irrigants the actual use remains limited in clinical practice. Only 10.8% of respondents reported having used nanoparticles in their endodontic treatments. Among the respondents who had incorporated nanoparticles, silver nanoparticles were the most commonly used, though some also employed chitosan and graphene nanoparticles. This lack of congruence between knowledge, attitude, and practice indicates that although dental professionals may be aware of the possible uses of the nanoparticles, there could be barriers to their use due to lack of availability, familiarity with protocols, or the availability of the material.

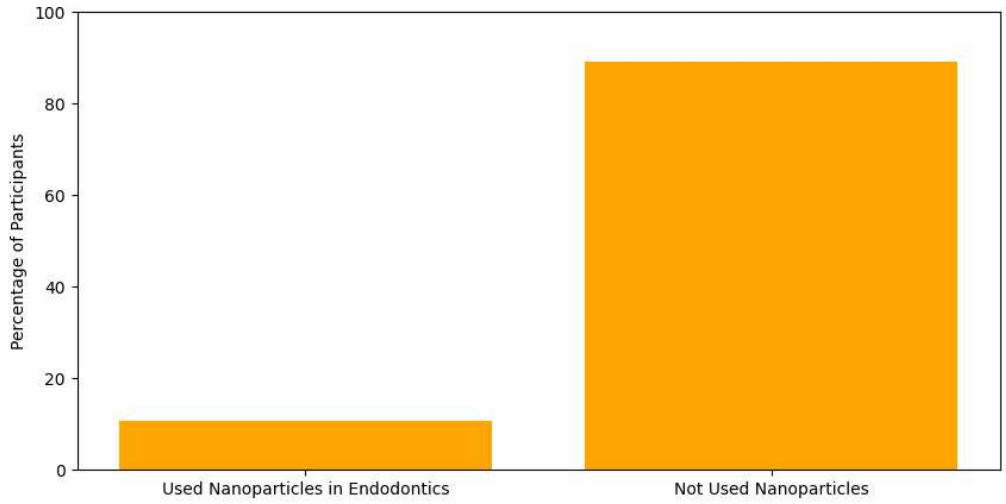

Fig 4: Usage of Nanoparticle-Based Irrigants in Clinical Practice.

4.5 Statistical Analysis

The chi-square analysis showed several statistically significant relationships, which may be considered as the main conclusions regarding the participants' responses. Firstly, awareness of silver nanoparticles as root canal irrigants was significantly associated with their use in clinical practice ($p = 0.02$). This means that the level of knowledge possessed by the participants about the antimicrobial properties of silver nanoparticles will enable them to incorporate the nanoparticles in their treatments. Another significant finding was the relationship between the perceived importance of bacterial biofilm removal and nanoparticle usage ($p = 0.01$), emphasizing that those who consider biofilm removal critical to treatment success are more inclined to utilize advanced antimicrobial solutions like nanoparticles. These findings therefore stress the need to create awareness and enhance education on the decision-making of embracing new technologies in the dental practice.

Such findings prove the possibility of employing nanoparticles in endodontic treatment; at the same time, they indicate that there is a significant gap between the concept and practice. Much more needs to be done to bring this gap to zero and ensure that dental care workers themselves have the right tools, knowledge, and materials to use nanoparticles appropriately in their practice.

5. Discussion

The findings of the present survey study also suggest the advantages and drawbacks of employing nanoparticles for endodontic applications. Again the percentage of the respondents who gave a very high rating to the importance of the tools was 94.1%, who said they had heard about nanoparticles, which is a good indication that people have a good general understanding of the term. Additionally, 69.2% of participants had specific knowledge about the antibacterial properties of silver nanoparticles, especially in bacterial biofilms in endodontic treatment. However having this considerable level of awareness, only 10.8% of the respondents had already applied nanoparticle-based solutions in their clinical practice. This gap between the knowledge and the practice shows that while dental professionals are aware of the possible benefits offered by nanoparticles, the application of nanoparticles in clinical practice is still limited by several barriers such as the lack of knowledge regarding the clinical protocols and the availability of the nanoparticle-containing materials (Ravindran, 2023). Most of the respondents' responses were positive about the use of nanoparticles in endodontics. A significant 91.8% of the participants said that nanoparticles have the possibility of enhancing root canal treatments.

Furthermore, 65.8% knew the use of silver nanoparticles as a root canal irrigant, this indicates the readiness of the dental professionals to use these materials as and when they are availed with the right tools and equipment. But at the same time, the data reveal that this enthusiasm has not led to the increased application of the technology in clinical practice. Some practitioners may be hesitant to use nanoparticles because at the moment there are no guidelines for their application or there is a limited number of products that can be used in practice (Wong et al., 2021). From these studies, it can be concluded that despite the recognition of the potential of using nanoparticles, professionals are hampered by the practical constraints of clinical practice. The statistical results offer valuable insight into the factors influencing the application of nanoparticle treatments. The study found that there was a significant relationship between the level of awareness of the antimicrobial properties of silver nanoparticles and their clinical use ($p = 0.02$) The findings suggest that as awareness of the properties of the silver nanoparticles increases, so will its use (Mallineni et al., 2023). Similarly, the perception of the importance of bacterial biofilm removal was significantly correlated to the use of nanoparticles ($p = 0.01$) indicating that education influences practice. Such results suggest that increasing knowledge and awareness, particularly through continuing professional development courses, may help to reduce the gap between awareness and practice (Mausavi et al., 2023). The participants appear to have adequate information regarding the bactericidal activity of nanoparticles but appear to lack adequate information regarding the green synthesis of nanoparticles. Only 29.3% of the respondents indicated that they knew that it is possible to synthesize silver nanoparticles using green synthesis such as plant extracts. This lack of information is a good area for dental education programs to bridge the knowledge gap about sustainability in the use of nanoparticles in endodontics. Such concepts may assist in the promotion of environmentally sustainable practices in dental care when introduced to practitioners and students (Ahmed et al., 2022). The results indicate that while dental practitioners possess a fair amount of knowledge about nanoparticles and their use in endodontic treatment, there are certain barriers to the use of nanoparticles in clinical practice. This has led to some of the major challenges such as limited access to nanoparticle-based products, lack of knowledge of clinical processes and procedures, and lack of standard procedures. This underscores the awareness not only that nanoparticles exist but also that more needs to be done to present teeth caregivers with the tools to incorporate nanoparticles into their practice. It is thus necessary to design and implement educational interventions such as programs and workshops that will help fill the gap of knowledge on the synthesis, uses, and application of nanoparticles (Mohan et al., 2020). Thus, this research provides a general overview of the knowledge, attitudes, and practices of dentists and other dental staff about nanoparticles used in endodontic treatment. People have a good understanding of nanoparticles and a positive attitude toward them, however, the utilization of nanoparticles in clinical practice is still very limited. The steps that can be taken to address this gap, especially the availability of nanoparticle-based material and the targeted educational campaigns, can significantly increase the application of nanoparticles in endodontic practice. More research in this field will be imperative for optimizing the use of nanoparticle-mediated therapies in dentistry.

6. Conclusion

The study was developed to assess the KAP of dentists and endodontists regarding nanoparticles in endodontic therapy. The survey result revealed that 94.1% of the participants claimed to have understood their applications, particularly concerning the use of silver nanoparticles as antimicrobial agents. However, given this high level of awareness and these generally favorable attitudes – 91.8% of the respondents understood the importance of nanoparticles in improving the existing root canal treatment, but there was poor application of the nanoparticles in clinical practice. Only 10.8% of the respondents said they had used nanoparticles in their endodontic practice,

which also suggested that there is a gap between the theoretical knowledge and the practical use of nanoparticles. The gap between awareness and usage suggests the fact that even though dental professionals understand the benefits of nanoparticles, there are barriers to the use of nanoparticles in the practice. These barriers may include; a lack of training on the use of nanoparticle-based techniques, restricted availability of nanoparticle-based materials, and information on the right procedures to use these materials. Moreover, the study showed that although dental professionals are open to change and are ready to adopt new technologies in their practice, they lack the right tools, information, and access to the resources needed to put into practice the new technologies in their treatments. This study therefore recommends more awareness and the use of training and educational programs that will increase knowledge on the use of nanoparticles in endodontics. The practitioners could gain the knowledge and skills for practical implementation of nanoparticle-based solutions from continuing education courses and seminars. Moreover, increasing the accessibility of nanoparticle-based materials and ensuring the availability of nanoparticles in clinical practice are the right ingredients for the improvement of nanoparticles in the endodontic process. Hence, it can be stated that, while dental professionals are aware of the nanoparticles and their benefits in endodontic treatment, it is not implemented in practice. This gap will need to be closed through education, training, and resource availability to ensure that nanoparticle-based therapies become part of standard dental care practice and thus improving patient outcomes.

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