



Applications of Silver Nanoparticles in Dentistry

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ABSTRACT

Nanotechnology is a booming field of research and innovation that aims at building materials on the scale of atoms and molecules. Essentially Nanotechnology is characterized as the plan, characterisation, creation and utilization of structures, gadgets and frameworks by controlled control of size and shape at the nanometer scale. It is a booming field of this 21st century. Silver Nanoparticles are known for their various physical, chemical and quantum properties that make them unique. They have got excellent antimicrobial properties that extend their applications nearly in every sphere of life. Apart from the antimicrobial property, they show excellence in their Anti-inflammatory and Anti-oxidation properties. Silver nanoparticles also have many optical, mechanical, biological and chemical properties that attribute to their enhanced performances in the evaluation and clinical assessments of mechanical devices and other biomaterials. Uses of Silver Nanoparticles in the field of dentistry is remarkable. Silver nanoparticles can be used in association with dental acrylic resins, intracanal medication and in implant coatings. The current study aims at discussing the applications of silver nanoparticles in various aspects of dentistry.

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INTRODUCTION

Nanotechnology is a booming field of research and innovation that aims at building materials on the scale of atoms and molecules. Essentially Nanotechnology is characterized as the plan, characterisation, creation and utilization of structures, gadgets and frameworks by controlled control of size and shape at the nanometer scale. The revolution created by

Nanotechnology in almost every aspect of science ranging from cosmetics to Biotechnology is tremendous (Rajeshkumar and Malarkodi, 2014). It's a contribution to the field of Dentistry is remarkable. Especially Silver nanoparticles had got great applications in Dentistry (Figure 1). Silver nanoparticles are nano-scale particles that are made of silver between 1nm and 100nm in size (Mohamed, 2014). Silver nanoparticles are largely composed of Silver oxide (Das, 2019). They have got a large surface to bulk silver atom ratio (Pranati et al., 2019). The uniqueness of the silver nanoparticles attributes to their physical and quantum properties (Rajeshkumar et al., 2019). They have got excellent antimicrobial properties that extend their applications nearly in every sphere of life (Vanaja, 2013). The Silver nanoparticles will go and bind with the sulfhydryl groups that are present in the bacteria's DNA and proteins. They cause unwinding of DNA, alter the hydrogen bonding and cause interference to Cell wall synthesis and cell division. Apart from the antimicrobial property, they have

got excellent Anti-oxidation and Anti-inflammatory properties. Silver nanoparticles also have many optical, mechanical, biological and chemical properties that attribute to their enhanced performances in the evaluation and clinical assessments of mechanical devices and other biomaterials. Their measurable results are characterized by their special mechanical and physical-chemical properties. Their increased surface area permits the coordination of various ligands. Therefore, they are well recognized for their usage in the diagnosis and treatment of many diseases. Applications of silver nanoparticles in dentistry is a growing field that has enhanced and stabilized various biomaterials and devices that are already in use in dentistry. Silver nanoparticles can be used in association with dental acrylic resins, intracanal medication and in implant coatings. Silver nanoparticles can also be used as an anti-carries formulation, in combination with local anaesthesia, in treatment of oral cancers. They also serve as an excellent choice of filler materials (Rajeshkumar, 2016; Rajeshkumar et al., 2016). Their application in Prosthodontics and Restorative dentistry is remarkable. The current study discusses the various applications of silver nanoparticles in dentistry.

More than 40 articles had been reviewed for the construction of the article. The articles were retrieved with the help of search engines like Google Scholar, Pubmed, Biorxiv and Chemrxiv. As this is a review article no approvals were required for the publication of the article

Silver Nanoparticles In Implantology

Titanium dental implants are the most widely used implants in dentistry (Zhao et al., 2009). The main complication of implantology is the presence of implant surface infection. In Spite of usage of aseptic surgical protocols during the surgery, infections tend to occur post-surgery (Rodriguez, 2017). Silver nanoparticles are greatly known for their antimicrobial properties. Thus incorporation of silver nanoparticles in the titanium implants may prevent peri-implantitis and other bacterial infections. Soo-Hyoen Choi et al. has compared the conventional uncoated implants with implants coated with silver loaded polydopamine coating. The pure titanium is immersed in dopamine hydrochloride or in the HCl buffer solution and in 50 mL silver nitrate solutions for about 24 hours with different concentrations for 30 minutes and thus the implant coating was formed (Choi et al., 2019). Results showed that there were significantly lower numbers of microbial colonies (*Streptococcus mutans*, *Porphyromonas gingivalis*) in the surface-modified titanium than those with the uncoated titanium (Choi et al.,

2019). The silver-coated implants maintained the lag phase of both the bacteria whereas the conventional implants did not maintain the same and the lag phase had been changed to exponential phase after 9 hrs for *Streptococcus mutans* and 15 h for *Porphyromonas gingivalis* (Choi et al., 2019). Bio Tian et al. has studied the antimicrobial properties of the implants with Silver nanoparticle-loaded hydroxyapatite coatings. The study has shown that the AgNP-HAC surfaces were found to be superior to a conventional titanium alloy in terms of induction of osteogenic differentiation in the stromal cells (Tian, 2016). Another study has shown that the antimicrobial effect of the nanoparticle coated implants to be about 64.6% which is statistically significant (Lampé et al., 2019). A study by Gunputh et al. has reported that the AgNP coated implants have exhibited more than 80 per cent microcidal activity on evaluation with LIVE/DEAD assay (Gunputh et al., 2020). The study has also shown that the coatings over the implants had very good stability. Li et al. have stated that the silver nanoparticles of bigger size which are of 5 to 25-nanometer diameter have got a greater antimicrobial effect than the nanoparticles of smaller diameter (Li, 2013a). A study by Lu et al. shows the significant antimicrobial properties of the Silver nanoparticle incorporated titanium implants (Lu, 2011). Including the distribution of size, density, adhesion, depth profile are the factors that attribute to the overall uniqueness of the silver nanoparticles (Zhao et al., 2009).

Silver Nanoparticles In Conservative Dentistry

Composite resins are restorative materials that are best known for their mechanical properties. They show excellent esthetics and load-bearing properties (das Neves et al., 2014). But the main disadvantage is that they accumulate more biofilm on their surface than any other restorative material, thus leads to plaque formation, which finally results in caries. Many researchers worldwide are working tirelessly in improving the quality and durability of the resins. On that note, It is seen that AgNP incorporation in the composite resins can enhance the antimicrobial properties of the composite resins. The Silver nanoparticles can be compacted within the composite resins by adjusting the quantity of the filler particles that are being used. Addition of silver nanoparticles to the composite resins can be achieved by making some slight modifications in the filler particles of the composite resins. A study by Patrícia Bolzan Agnelli das Neves et al. states that the silver nanoparticle incorporated composite resins had become more resistant to biofilm formation and at the same time there had been no compromise in the physical and mechanical prop-

erties of the composites (das Neves *et al.*, 2014). Another study by Shahin Kasraei *et al.* has examined the antimicrobial activities of the Silver nanoparticle incorporated composite resins. Direct contact test was done for the evaluation (Kasraei *et al.*, 2014). The modified resins had shown higher antibacterial effects against the oral pathogens, namely *Streptococcus mutans* and *Lactobacillus* (Kasraei *et al.*, 2014). The study results of a similar study by Li *et al.* show that the biofilm formation and acidity were reduced by the AgNP incorporated Composite resins and the number of microorganisms had been significantly reduced (Li, 2013b). A study by Zhang *et al.* shows that there is no change in the cytotoxicity of the primer due to the incorporation of AgNPs in the adhesive systems (Zhang, 2013). Thus modified composite resins with silver nanoparticles embedded are much more antimicrobial than standard composite resins.

Silver Nanoparticles In Endodontics

Most of the Endodontic treatment failures are attributed to the formation of secondary caries (Leonardo, 1984). The Bacteria are the ones that cause secondary caries and peri radicular infections. The formation of secondary caries can be prevented by performing a proper cleaning and shaping of the root canal with good disinfectants. Sodium Hypochlorite is the best root canal irrigant known till date (Leonardo, 1984). But their cytotoxic activity towards the periapical tissues has paved the way for new attempts in discovering a root canal irrigant that is potent as Sodium hypochlorite and with relatively less toxicity. On that note, Silver nanoparticle solutions can be considered to be used as a final root irrigant. A study by Samiei M *et al.* had tested the antibacterial activities of Sodium hypochlorite and Silver nanoparticle solutions against the *Enterococcus faecalis* bacterial species. The results show that there was no difference between 5.25% NaOCl and 0.005% AgNPs (Samiei, 2013). Silver nanoparticle solution is more effective than NaOCl as it works at a relatively lower concentration. But a study by Rodrigues *et al.* contradicts the above statement reporting that Silver nanoparticle solution was not as effective as conventional root canal irrigants when it was tested against *E. faecalis* (Rodrigues *et al.*, 2018). Another study results show that Gallic acid mediated synthesis of silver nanoparticles of 10 nm had presented a bactericidal activity against *E. faecalis* and this was same as that of sodium hypochlorite solution (González-Luna, 2016). It also states that silver nanoparticles have the capacity to remove smear layers (González-Luna, 2016).

Another advancement is the development of Silver nanoparticle incorporated Gutta perchas in obturating a root canal. Gutta Perchas is the most commonly used root canal obturating materials. AgNPs incorporated Gutta perchas can aid in the prevention of accumulation of microbial colonies in the root canals. A study by Shantiaee *et al.* has compared the biocompatibility of the nanosilver incorporated Gutta perchas. The study had compared the nanosilver-coated gutta-perchas with the normal gutta-perchas on mouse fibroblasts in order to measure their cytotoxicity (Shantiaee, 2011). After 24 hrs, the cytotoxicity values were measured. It was found that the cytotoxicity values of both of them were similar. The cytotoxicity values of nanosilver-coated gutta-perchas reached the lowest after one week (Shantiaee, 2011). Though the significance is only quite higher than the conventional Gutta perchas, Nanosilver Gutta Perchas is still better than the former as they have better antimicrobial properties and relatively lesser cytotoxicity.

Silver Nanoparticles In Prosthodontics

Dental Porcelain ceramics are the most used fixed denture prosthesis. They are mostly used in anterior teeth replacements for their excellent Esthetics. However, they are brittle and tend to get fractured easily. A study shows that Vickers hardness and Fracture toughness had been increased by the incorporation Of Silver nanoparticles in the porcelain material (Uno *et al.*, 2013). Another study shows that Silver Nanoparticles had the capability of enhancing the porcelain prosthesis mechanical properties (Fujieda, 2012). The study shows that AgNPs also increase Young's modulus of the prosthetic material (Fujieda, 2012). In this aspect, Silver nanoparticles are found to be more effective than the Platinum Nanoparticles.

Silicone artificial substitutions are used in making Maxillofacial prosthesis (Meran, 2018). These prostheses are used in replacing the lost facial parts, also in restoring and maintaining the health of the tissues and in improving esthetics. The factors that affect their stability are infection and contamination. Nanosilver incorporated prosthesis has shown activity against the *Candida albicans* species without causing any cytotoxic effects on the fibroblast cells (Meran, 2018). The incorporation of AgNPs had no effects or least effects on the colour of the prosthesis (Han, 2010). Denture bases coated with Silver nanoparticles can prevent Stomatitis.

Silver Nanoparticles In Orthodontics

The worst problem in dental care is white spot lesion formation on enamel during the Orthodontic treatment (Akhavan, 2013). The lactic acid

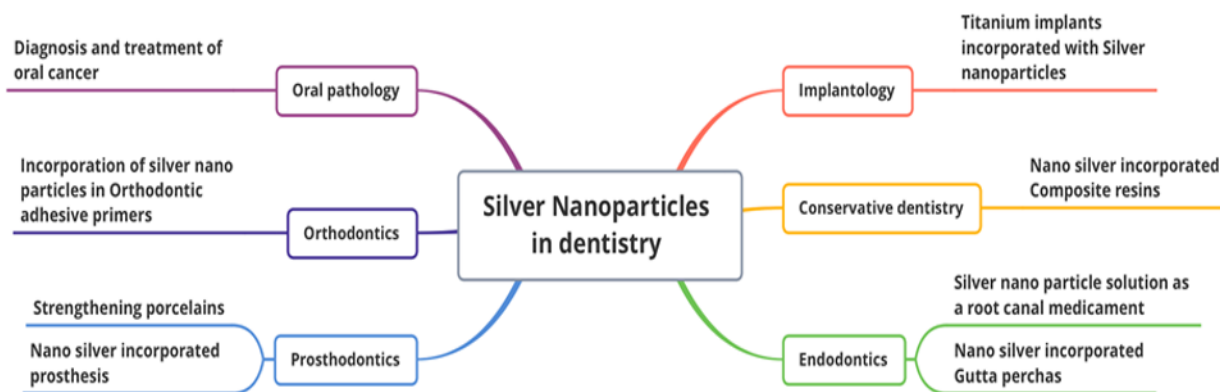


Figure 1: Silver nanoparticles in Dentistry

production by bacterial species such as *Streptococcus mutans* and low oral pH attributes to the White spot lesion formation. On the other hand, removal of dental plaque mechanically is very difficult with the obstructing Orthodontic brackets. Preventing Orthodontic adhesives for a longer period is important in preventing enamel demineralisation. The AgNp incorporated adhesive primer had inhibited the growth of *Streptococcus mutans* (Mohamed, 2014). It is found to enhance the dispersion and penetration of the antimicrobial agents onto the surface of the enamel than the other composites which attributes to its lower viscosity and wettability (Mohamed, 2014). The Silver nanoparticles had no effects on the primer's physical and chemical properties.

Silver Nanoparticles In Oral Cancer Therapy

Oral cancer is a more prevalent and fulminant cancer that invades tissues, undergoes metastasis and finally culminates in the death of the patient (Alkis et al., 2015). Oral cancer is often diagnosed at an untreatable condition where the cancerous cells are malignant and have developed immunity against the therapeutic drugs (El-Sayed et al., 2005). A study by Kah et al. has explained the mechanism by which the nanoparticles that are conjugated with nanoparticles can target and illuminate the tumour cells. It was done with the help of optical imaging technique (Kah, 2007). Silver Nanoparticles are extensively applied in drug delivery systems. Silver nanoparticles have caused better selective accumulation of cis Diamine dichloro platinum in the cancer cells while decreasing its ability to undergo metastasis (Ge and Kang, 2011). It makes the particles to flow in the circulatory system for a long time so that it can facilitate their accumulation specifically onto the tumour tissues.

CONCLUSION

The widespread use of the nanosilver particles in various aspects of Dentistry attributes for the excellent antimicrobial properties of the AgNPs. The review article had discussed the various uses of AgNPs in different fields of dentistry such as Implantology, Conservative Dentistry, Restorative Dentistry, Prosthodontics, Orthodontics and in Oral Cancer Therapy. Further investigations of Silver nanoparticles in vivo have to be carried out to enlighten and increase the clinical application of Silver Nanoparticles in every aspect of Dentistry.

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Conflict of Interest

The authors declare that there is no conflict of interest for this study.

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