International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 9(E); September 2018; Page No. 15538-15541
DOI: http://dx.doi.org/10.24327/ijcar.2018.15541.2840

Review Article

EFFECTIVENESS OF SILVER NANOPARTICLES ON PERIODONTAL SURGERY – A LITERATURE REVIEW

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A R T I C L E I N F O

Article History:

Received 06th June, 2018
Received in revised form 14th July, 2018
Accepted 23rd August, 2018
Published online 28th September, 2018

Key words:

Silver nanoparticles, Antimicrobial, Antiadhesive, Periodontal regeneration, Cytotoxicity

A B S T R A C T

Background: Periodontal health has become an integral part of the oral health. Various treatment modalities have been evolved to maintain the periodontal health intact. The success rate of these periodontal treatment modalities can be questionable due to the commonly occurring post-operative infections. Hence emerged the attempt of using silver nanoparticles in dental materials and its antimicrobial effect in dentistry.

Review Results: Numerous studies revealed its significant antimicrobial and antiadhesive property and have also explained its activity in periodontal procedures by impregnating in membranes, scaffolds and implants. Unfortunately, very limited clinical trials have been conducted to prove its efficacy and to state its side effects.

Discussion: Various mechanisms have been contributed towards the antibacterial effect of silver nanoparticles. Available literatures suggested the prevention of bacterial adhesion, termination of mitosis, production of reactive oxygen species and disruption of cell membrane as the possible mechanisms involved in exhibiting antibacterial action.

Conclusion: Though silver nanoparticles have been used actively in the field of medicine for past few decades, worldwide various studies are still in process to prove its efficacy in dentistry.

Clinical Significance: With the limited clinical trials and enormous in vitro studies, silver nanoparticles were considered to be a potent antimicrobial agent reducing post-operative infections in periodontal surgeries.

INTRODUCTION

Periodontal health has become an integral part in oral health maintenance in recent times. It also depicts the systemic condition of the patient. Of late, various diagnostic aids and treatment modalities have evolved to achieve and maintain periodontal function and esthetics. Most of the periodontal surgeries aimed at achieving complete regeneration of their structures which is yet to be accomplished. Oral immunology and microbiology plays a vital role to reach this goal. One of the recent attempts to combat the oral pathogens is the use of silver nanoparticles in periodontal surgeries. Silver nanoparticles is used in medical as well as dental application for past few decades. Due to its antimicrobial activity, it is used in various scaffolds to enable the success of periodontal regeneration.

REVIEW RESULTS

Available literature has been categorized as the following

- Studies evaluating antimicrobial effects of silver in membranes
- Studies evaluating antimicrobial effects of silver in scaffolds for bone regeneration
- Studies evaluating antimicrobial effects of silver in dental implant surfaces

Studies Evaluating Antimicrobial Effects of Silver in Membranes

Li *et al*. analyzed GBR with a silver substituted nanohydroxyapatite, titanium nanoparticles and polyamide 66 membrane and assessed their efficiency based on bone formation and cytocompatibility. The in vitro results revealed better osteoblastic cell affinity, cell attachment and cell proliferation but the in vivo results failed to show complete closure of 5mm bone defects within 8 weeks of its implantation on Sprague-Dawley rats[1].

Ye *et al*. found that the Ag-nHA-nTiO2/ PA 66 has no negative effects on MG 63, despite it more favored the cell affinity and excellent tissue compatibility[2]. In addition to it, it was helpful in reducing the inflammatory response and there by promoting bone regeneration[3].

Cohen *et al*. studied the effectiveness of propylene mesh coated with nanocrystalline silver particles. The results showed increasing zone of inhibition as they increase the dosage of

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silver nanoparticles and apparently exhibited no zone of inhibition for uncoated mesh[4].

Studies Evaluating Antimicrobial Effects of Silver In Scaffolds For Bone Regeneration

Wu *et al*. demonstrated the effective release of Ag ion at the bone-implant surface with the use of Ag-nHA-nTiO2/PA 66 antimicrobial scaffold. These scaffolds produced excellent mechanical support and proliferation in the bone augmentation techniques[5].

You *et al*. conducted a comparative analysis between the CCS [collagen / chitosan hybrid scaffold] and silver nanoparticle coated CCS to evaluate their antimicrobial efficiency. The results suggested a statistically significant antimicrobial effect at higher concentration of nAg-CCS against E. coli and S. aureus[6].

Patrascu *et al*. studied various compositions of HA-Ag samples obtained by plasma sputtering (10, 100 and1000 ppm Silver nanoparticle). In vitro experimentation revealed inhibitory action against E. coli even at low silver content and thus concluded that it inhibits the growth of the E. coli about 43% at 10 ppm concentration. They also revealed that their antimicrobial property increased corresponding to the composition of silver nanoparticle. By increasing the Silver nanoparticle content, the antimicrobial activity also simultaneously increased (51% inhibition rate for 100 ppm and 77% for 1000 ppm of Silver nanoparticle)[7].

Saravanan *et al*. studied the effectiveness of silver nanoparticles incorporated in the scaffold containing chitosan and nano hydroxyapatite and revealed that the zone of inhibition of CS/nHAp/nAg scaffold against E.coli and S.aureus was found to be 13.34±2.75 mm and 12.78±1.10 mm respectively and the zone of inhibition of CS/nHAp scaffold against E.coli and S.aureus was found to be 4.75±1.19 mm and 4.10±1.17 mm respectively. Thus they concluded that the scaffold with silver nanoparticles exhibited potent antibacterial effect in bone reconstruction surgery. These scaffold were also found to be non-toxic for rat osteoprogenitor cells and human osteosarcoma cell lines[8].

Studies Evaluating Antimicrobial Effects of Silver In Dental Implant Surfaces

Seciniti *et al*. conducted an in vivo study by applying the bacteria to the surgical sites on iliac crests of rats and implanted Ti screws coated with and without Silver nanoparticle. Surgical sites were subjected to Transmission (TEM) and Scanning electron microscopy (SEM) after 28 days. The results revealed that the screws coated with silver nanoparticles showed no biofilm formation. Thus the study confirmed that silver nanoparticles have antibacterial activity with the prevention of biofilm formation[9].

Juan *et al*.compared the antibacterial effect of titanium coated silver nanoparticle (Ti-nAg) and Ti polished implant surface and concluded that Ti-nAgsurface exhibited excellent antibacterial activity about 94% which inhibited the growth of S.aureus and E.coli than the polished titanium specimen[10].Flores *et al*. studied theTi/TiO2 surface of implants modified with citrate-capped Silver nanoparticles and exhibited P.aeruginosa resistance to colonization[11].

Study was conducted for evaluating the antimicrobial effect using titania nanotubes incorporated with the silver. Invitro results exhibited that the NT-Ag killed the planktonic bacteria in the first few days with no decline in the activity over 30 days suggesting a remarkable longterm effect. The study also exhibited that Ag showed some level of cytotoxicity, which could be overcome by the controlling of Ag+ release rate. It was also found to promote biointegration.

Mo *et al*. demonstrated the antiadhesive efficiency and bactericidal property of the rough surfaced titanium plates coated with silver-hydroxyapatite / titania nanocomposites (nAg-HA/TiO2) against the Gram-negative bacteria periodontal pathogens (P.gingivalis, F. nucleatum, S.mutans). The antimicrobial film was found to be suppressed to about 10% after anaerobic incubation for 3 hours and showed less bacterial adherence to nAg-HA/TiO2 coated surfaces[12].

DISCUSSION

Silver nanoparticles are nanometer-sized particles of silver that are <100 nm in size. Silver when used alone or in other combination with other compounds had been proven to have potent antimicrobial effect which includes antibacterial as well as antiviral activity[13]. This compound has been used in various forms in the field of dentistry. Studies showed that its efficacy varies based on their form. Ag+ salts have limited antimicrobial activity due to interfering effects of salts in the action of silver ions; this defect has been overcome by the use of Silver nanoparticle[14]. Nanoparticle being very tiny in their size, it has greater surface-to-volume ratio, hence is more effective in reactivity[15, 16]. Pal*et al* stated that triangular shaped Silver nanoparticle has the greater bactericidal action specifically against E.coli[17].

Various mechanism of action of silver nanoparticles for its antimicrobial activity have been proposed. They are as follows

- By preventing the bacterial adhesion and inhibiting the microbial activity.
- By terminating the mitosis in prokaryotes[18].
- By reactive oxygen species production, as the silver nanoparticles enter into the bacterial cell through endocytosis and attacks the mitochondria which causes the oxidation of the DNA leading to DNA unwinding and prevention of the cell reproduction[19,20].
- By disruption of the cell membrane when positively charged silver ions readily attract towards the negatively charged bacterial cell membrane causing leakage of the cell contents such as lipopolysaccharide and membrane proteins[21].

Sondi and Salopek elucidated the ‘pit’ shaped formation in the cell membrane of the E.coli which leads to the leakage of the cell contents and cell death[22]. This mechanism occurs commonly in gram negative bacteria than in gram positive bacteria as it contains about 3-20 times of peptidoglycan layer thickness in the outer cell membrane.

The uses of Silver nanoparticles in periodontal surgeries are progressively increasing. It is used as impregnation in membrane, scaffold and implants.

Membranes in periodontal surgery are used as barrier devices in GTR/GBR procedures that helps in preventing the rapid in growth epithelial cells in the bony defect[23, 24]. These membranes tend to get infected postoperatively. In order to overcome this, antimicrobial membranes were developed. One such attempt includes silver nanohydroxyapatite crystals

impregnated membrane. This membrane exhibited an action upon osteoblast like cells and promoted significant cell compatibility and bone regeneration[2]. Additionally, it had no cytotoxic effects on osteoblast like cells and showed increased zone of inhibition.

Basically grafts act as a scaffold on which the bone cells can adhere and form new bone during bone regeneration[25]. The common drawback encountered in this procedure are post-operative infections. Studies aimed at reducing this post-operative complication used scaffold coated with nanosilver and chitosan and found reduced infection in the bone regeneration due to its antimicrobial activity. The antimicrobial activity was found to be directly proportional to the concentration of silver nanoparticle on collagen hybrid scaffolds and membranes[4,6].

Apart from membranes and grafts, the invasion of silver nanoparticles has reached dental implants as well. Long term success of the dental implant not only depends on the Osseointegration but also on the reduction of the microbial infection after implant placement. The prevalence of peri-implant mucositis and peri-implantitis is found to be 43% and 50% respectively[27].Studies overcome these infections by incorporation of silver nanoparticles on implant surface which effectively hinders the formation of bacterial biofilm, lowers the bacterial adherence and exhibits a cidal effect on planktonic bacteria[9]. The antibacterial effect of silver nanoparticles coated titanium surface is more effective specifically against E. coli and S. aureus than the polished titanium surface[10]. Liao *et al*. found that the silver nanoparticles coated titanium implant surface shows the more predominant antibacterial and antiadhesive effects against A.actinomycetemcomitans and P.gingivalis[28].

Though silver has better inhibitory effects over microorganisms, to some extent it shows certain level of toxicity over thenormalcells. Invitro studies reported that the Silver nanoparticles(50 nm) had cytotoxic effects on osteoblasts (OBs) and osteoclasts (OCs) depending on their concentration[29], but showed no detectable cytotoxicity on cultured human gingival fibroblasts[28,30]. These silver nanoparticles on exposure to more than 300 mg may result in the liver damage[31].

CONCLUSION

Silver nanoparticles have been proven to have promising antimicrobial and antiadhesive property thus promoting its use in periodontal surgeries. The risk of post-operative infection endangering the success of periodontal regenerative procedures can be effectively overruled by the use of appropriate concentration of silver nanoparticle. This review necessitates the need for further in vivo human clinical trials for its efficient usage and application in the clinical practice.

Clinical Significance

Though many clinical studies are yet to be conducted using silver nanoparticles in the field of dentistry, the clinical studies were considered based on in vitro clinical studies. They suggested that silver nanoparticles to play a pivotal role towards periodontal regeneration in reducing post-operative infections effectively.

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How to cite this article:

Aswin.M *et al*.2018, Effectiveness of Silver Nanoparticles on Periodontal Surgery – a Literature Review. *International Journal of Current Advanced Research,* 07(9), pp. 15538-15541. DOI: http://dx.doi.org/10.24327/ijcar.2018. 15541.2840

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