International Journal of Dentistry and Oral Science (IJDOS)
ISSN: 2377-8075

Recent updates on Silver Nanoparticles in Orthodontics - A Perspective Note

Research Article

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Abstract

Nanotechnology over past decades, has emerged as a mainstay in various fields and has been employed in various biomedical applications. It is currently being extensively used in the manufacture of drugs, as a diagnostic aid, in implants, as a prosthetic material and in tissue engineering. With the recent introduction of advanced Nano robotic models in local anesthetic procedures, the applications and importance of nanotechnology in the field of healthcare have gained renewed impetus. This review primarily throws light on the current applications of silver nanoparticles in the field of Dentistry, emphasizing on orthodontics in particular, with regard to their antimicrobial properties, anti-cariogenic effects, Nano silver coating applications of orthodontic brackets, micro implants, biocompatibility analysis and fixed orthodontic appliances.

Keywords: Nanotechnology; Biomedical; Silver Nanoparticles; Orthodontics; Dentistry.

Introduction

Currently, nanoparticles are employed extensively in various biomedical applications primarily in the fields of medicine and dentistry. They are incorporated in various forms in the treatment of dental infections [1]. Nanoparticles are usually chosen according to their physical, chemical and biological characteristics of their nanostructures [2]. In addition, nanotechnology is widely applied in the field of biomaterials as nano composites, nano ionomers and nano fillers. Newer emerging technologies in the field of orthodontics, namely, Nano robots are being employed currently for enabling direct accelerated orthodontic tooth movement [3, 24].

There is already a large body of published research justifying the significant antimicrobial, antioxidant and anti-inflammatory potentials of silver nanoparticles (AgNPs). They are widely employed in the field of dental practice and other biomedical applications [4, 5]. Moreover, silver nanoparticles are also used in the reduction of biofilm formation and in the prevention of enamel demineralization. They possess significant antibacterial activity against various multi resistant microorganisms [6-8]. The aim of this review is to briefly discuss the applications and the current status of silver nanoparticles in the field of orthodontics.

Silver nanoparticles in Orthodontics

White spot formation is one of the common adverse effects of Orthodontic treatment. Fixed orthodontic appliances affect the properties of oral microbial flora and pave the path for the growth of acidogenic bacteria like S. mutans and Lactobacilli in saliva This eventually produces dental plaque [25].

An in vitro evaluation was conducted to determine the antimicrobial potential of the silver nanoparticles with inclusion to an orthodontic primer. The study revealed a significant reduction in the presence of S. mutans after 15 days of cemented teeth with the AgNPs doped primer [28].

Li et al., developed a new model by incorporating AgNPs to an adhesive system to evaluate the antibacterial potential and subsequently its antimicrobial activity. It was observed that AgNPs lowered the CFU number and the production of lactic acid on biofilms in the adhesive surface, demonstrating that the AgNPs-containing adhesives possess significant antibacterial ability [9, 10]

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Received: May 28, 2021
Accepted: June 17, 2021
Published: June 18, 2021

Citation: Aravind Kumar S. Recent updates on Silver Nanoparticles in Orthodontics - A Perspective Note. *Int J Dentistry Oral Sci.* 2021;8(6):2755-2757.
doi: http://dx.doi.org/10.19070/2377-8075-21000540

Nanoparticle coated Orthodontic micro implants

Microbial growth around the dental implants leads to the loosening of the implants. A study was conducted to investigate the antibacterial properties of surface treated titanium micro-implants with silver nanoparticles (AgNPs). The authors employed two methods. Scanning electron microscopy results revealed that a minor quantity of AgNPs were sparsely deposited on the Ti-AgNP surface with the first method, while, a layer of AgNP-coated biopolymer extended along the Ti-BP-AgNP surface in the second method. After 24 hours of incubation it showed no antibacterial growth around the titanium micro implants with silver nanoparticles [16, 20].

Antimicrobial properties of silver nanoparticles

Shfiei et al., assessed the antibacterial activity of silver (Ag) and titanium dioxide (TiO2) nanoparticles incorporated into an experimental dentin bonding agent formulation. Results indicated that these metal-based nanoparticles exhibited dose-dependent bactericidal activities. The AgNPs had higher antibacterial activity compared to the TiO2 nanoparticles. Incorporation of these nanoparticles into dental adhesives is a promising way to reduce the risk of secondary caries [18].

In another study, the antimicrobial efficacy of silver, titanium dioxide and zinc oxide nanoparticles were evaluated against Streptococcus mutans [21] In this study, a significant difference was noted in the colony forming units among all three concentrations of silver (Ag), titanium dioxide (TiO2) and zinc (ZnO) nanoparticles.

The antimicrobial effects of nanoparticles were concentration dependent. Inter group comparison of colony forming units with 1%, 0.5% and 0.25% of the test compounds revealed that the colony forming units on the ZnO nanoparticles demonstrated the highest value followed by TiO2 and the least were with that of the AgNPs.

Mechanical properties of nanoparticles

A study on AgNPs was conducted by an in situ method on orthodontic elastomeric modules (OEM). Silver nitrate salts, as metal-ion precursors and extract of the plant Hetheroteca inuloides (H. inuloides) were used as bio reductants via a simple and eco-friendly method. The antibacterial properties of OEM with AgNPs were evaluated against the clinical isolates, namely, Streptococcus mutans, Lactobacillus casei, Staphylococcus aureus and Escherichia coli using agar diffusion tests [12]. The results suggested the potential of the material to combat dental biofilms and in turn decrease the incidence of demineralization in dental enamel, ensuring their performance in patients with orthodontic treatment.

Sheer bond strength of Orthodontic brackets

Mona Riad et al., evaluated the shear bond strength of orthodontic adhesive system containing antimicrobial silver nanoparticles on bonding of metal brackets to enamel. Results of the study indicated that the bond strength of the adhesive system containing no silver nanoparticles was statistically higher. Addition of silver nanoparticles to the bonding system affected the shear bond strength of the orthodontic brackets to enamel [9, 11].

Sonja Blocher et al., demonstrated the addition of micro silver or AgNPs to an orthodontic primer which affected shear bond strength (SBS) and bracket/adhesive failure. The findings suggested that the addition of small concentrations of microsilver or nanosilver particles affect neither SBS nor ARI scores. Addition of nanosilver particles resulted in silver spots in the remaining primer visible under 10× magnification [15, 19, 23].

Reduction of frictional resistance –Silver nano coated wires

A study was conducted by Shah et al., to compare and evaluate the frictional resistance of silver coated and uncoated stainless steel (SS) wires. The findings showed that silver coated wires did not affect the frictional resistance or reduced it as compared with uncoated wires [26].

Applications of silver nanoparticles in removable retainers

A clinical study was conducted to evaluate the effect of AgNPs incorporated into acrylic baseplates of orthodontic retainers on Streptococcus mutans colony-forming units. The study concluded that the addition of AgNPs to the acrylic plate of retainers had a strong antimicrobial effect against S mutans under clinical conditions [27].

Nano coated orthodontic cement

A study was conducted to develop an antimicrobial orthodontic band cement for the prevention of white spot lesions using a novel process which generates silver nanoparticles (AgNP) in situ. The findings revealed that the antimicrobial orthodontic band cement had comparable mechanical properties to controls, controlled and sustained Ag+ ion release with significant bacterial inhibition in vitro, along with excellent biocompatibility [21, 22].

Nano silver coated orthodontic adhesives

Incorporation of AgNPs into orthodontic adhesives stimulated or maintained the shear bond strength of an orthodontic adhesive while expanding its resistance to oro-dental pathogens [18].

Biocompatibility assessment of orthodontic composites

Biocompatibility of nano silver coated brackets were evaluated in vivo in Wistar albino rats. It was observed that the nano silver possessed anti-bacterial effects and showed a significant anti-inflammatory response. It also showed a significant reduction in tooth decay and demineralization during orthodontic procedures [11, 13, 14].

Conclusion

In the past decades, nanotechnology research in the area of Dentistry has primarily been focused on the applications of silver nanoparticles in orthodontics, oral implantology, endodontics and periodontics. Nanotechnology has been extensively applied in various procedures in orthodontics. Much of the research on silver nanoparticles in this field has been carried out using in vitro and in vivo models. Silver nanoparticles have been found to be relatively safer which makes them the primary choice material to

be incorporated in dental implants, orthodontic adhesives and orthodontic wires. Further research is required to study the translational applications of silver nanoparticles in orthodontics and also to extend their uses in other areas of Dentistry.

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